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Forsmark site investigation

RAMAC and BIPS logging in borehole KFM02B and KFM08D

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May 2007

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Abstract

This report includes the data gained in geophysical logging operations performed within the site investigation at Forsmark. The logging operations presented here includes BIPS and borehole radar (RAMAC) logging in the core-drilled boreholes KFM02B and KFM08D. All measurements were conducted by Malå Geoscience AB during February 2007.

The objective of the radar surveys is to achieve information on the rock mass around the borehole. Borehole radar is used to investigate the nature and the structure of the rock mass enclosing the boreholes.

The objective of the BIPS logging is to achieve information of the borehole including occurrence of rock types as well as determination of fracture distribution and orientation.

This report describes the equipment used as well as the measurement procedures and data gained. For the BIPS surveys, the results are presented as images. Radar data is presented in radargrams and the identified reflectors are listed.

The borehole radar data quality from both KFM02B and KFM08D was relatively good, but in some parts of lower quality due to high electric conductivity of the borehole fluid. This conductive environment reduces the possibility to distinguish and interpret possible structures in the rock mass which otherwise could give a reflection. However, the borehole radar measurements resulted in 105 identified radar reflectors of which 25 were orientated (dip/strike) in KFM02B. The corresponding figures for KFM08D are 251 and 37.

The BIPS images from KFM02B are of very high quality and result in easy interpreted images for the geological core logging. In KFM08D the images are not good; bad water quality and discoloring of the borehole walls induced from the drilling limits the visibility.

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Forsmark. Mätningarna som presenteras här omfattar BIPS-loggning och borrhålsradarmätningar (RAMAC) i kärnborrhålen KFM02B och KFM08D. Alla mätningar är utförda av Malå Geoscience AB under februari 2007.

Syftet med radarmätningarna är att samla information om bergmassan runt borrhålet. Borrhålsradar används till att karakterisera bergets egenskaper och strukturer i bergmassan närmast borrhålet.

Syftet med BIPS loggningen är att skaffa information om borrhålet inkluderande förekommande bergarter och bestämning av sprickors fördelning och deras orientering.

Rapporten beskriver utrustningen som använts liksom mätprocedurer och en beskrivning och tolkning av data som erhållits. För BIPS loggningarna presenteras data i form av plottar längs med borrhålet. Radardata presenteras i radargram, och en lista över tolkade radarreflektorer ges.

Borrhålsradardata från KFM02B och KFM08D var relativt bra, men tidvis av sämre kvalité, troligen till stor del beroende på en elektrisk konduktiv miljö. En hög elektrisk konduktivitet minskar möjligheterna att identifiera strukturer från borrhålsradardata. Dock har 105 radarreflektorer identifierats i KFM02B, varav 25 är orienterade (strykning och stupning). Motsvarande siffror för KFM08D är 251 och 37.

Kvalitén på BIPS bilderna från KFM02B är mycket bra. Däremot är förutsättningarna betydligt sämre i KFM08D, dålig vattenkvalité och svärtning av borrhålsväggen från borrningen försämrar kvalitén på bilderna.

Contents

1 Introduction

This document reports the data gained in geophysical logging operations, which is one of the activities performed within the site investigation at Forsmark. The logging operations presented here includes TV-logging (BIPS) and borehole radar (RAMAC) in the core-drilled boreholes KFM02B and KFM08D. The work was carried out in accordance with activity plan AP PF 400-07-002. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

This report includes measurements from approximately 0 m to approximately 569 m in borehole KFM02B and from 0 to 927 m in KFM08D. The borehole diameter is in KFM02B 75.8 mm and in KFM08D 77.3 mm.

All measurements were conducted by Malå Geoscience AB during February 2007. Figure 1-1 shows the location of the boreholes.

The used investigation techniques comprised:

- Borehole radar measurements (Malå Geoscience AB's RAMAC system) with dipole and directional antennas.
- Borehole TV logging with the Borehole Image Processing System (BIPS) which is a high resolution, side viewing, colour borehole TV system.

Original data from the reported activity are stored in the primary database Sicada. Data are traceable in Sicada by the Activity Plan number (AP PF 400-07-002). Only data in databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the P-report, although the normal procedure is that major revisions entail a revision of the P-report. Minor revisions are normally presented as supplements, available at *www.skb.se.*

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	**Number**	**Version**
BIPS- och Radar-loggning i KFM02B och KFM08D	AP PF 400-07-002	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för TV-loggning med BIPS	SKB MD 222.006	1.0
Metodbeskrivning för borrhålsradar	SKB MD 252.020	3.0

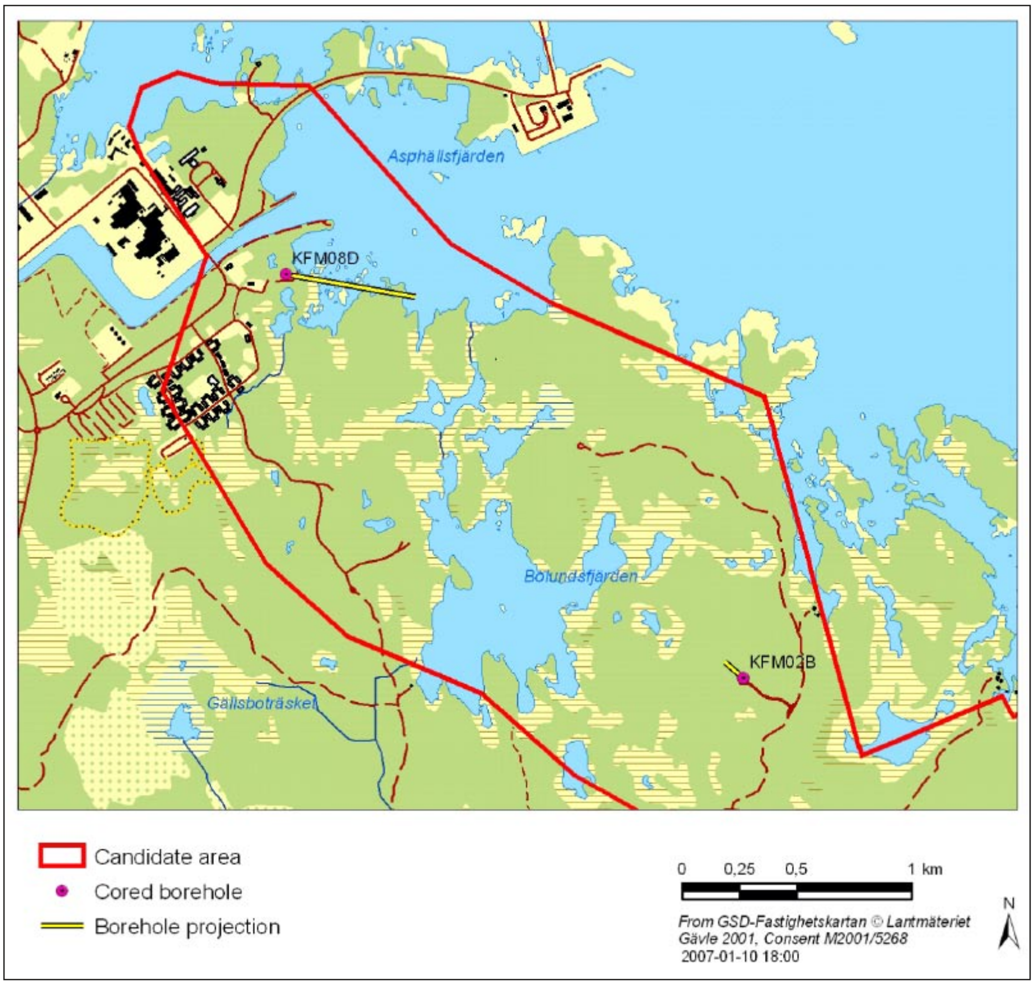


Figure 1-1. *Overview over the Forsmark investigation area, showing the location of the boreholes KFM02B and KFM08D surveyed and presented in this report.*

2 Objective and scope

The objective of the radar and BIPS surveys is to achieve information on the borehole conditions (borehole wall) as well as on the rock mass around the borehole. Borehole radar is engaged to investigate the nature and the structure of the rock mass enclosing the boreholes, and borehole TV for geological surveying of the borehole including determination of fracture distribution and orientation.

This report describes the equipment used as well as the measurement procedures and data gained. For the BIPS surveys, the results are presented as images. Radar data are presented in radargrams and the identified reflectors are listed.

3 Equipment

3.1 Radar measurements RAMAC

The RAMAC GPR system owned by SKB is a fully digital GPR system where emphasis has been laid on fast survey speed and easy field operation. The system operates dipole and directional antennas (see Figure 3-1). A system description is given in the SKB internal controlling document MD 252.021.

The borehole radar system consists of a transmitter and a receiver antenna. During operation an electromagnetic pulse, within the frequency range of 20 MHz up to 250 MHz, is emitted into the bedrock. Structural features, e.g. a water-filled fractures with sufficiently different electrical properties, causes reflected pulses, which are recorded by the receiver.

3.2 TV-Camera, BIPS

The BIPS 1500 system used is owned by SKB and described in SKB internal controlling document MD 222.005. The BIPS method for borehole logging produces a digital scan of the borehole wall. In principle, a standard CCD video camera is installed in the probe in front of a conical mirror (see Figure 3-2). An acrylic window covers the mirror part and the borehole image is reflected through the window and displayed on the cone, from where it is recorded. During the measuring operation, pixel circles are grabbed with a resolution of one pixel per degree.

The system orientates the BIPS images according to two alternative methods, either using a compass (in near-vertical boreholes) or with a gravity sensor (in inclined boreholes).

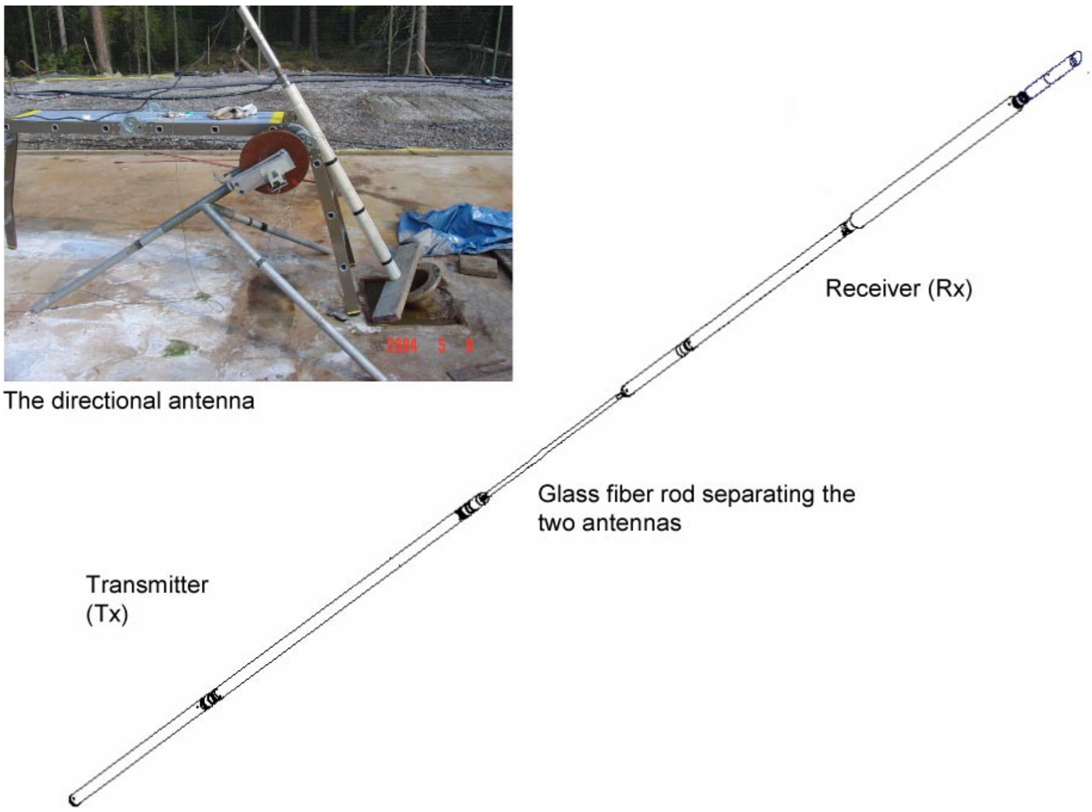


Figure 3-1. Example of a borehole radar antenna.

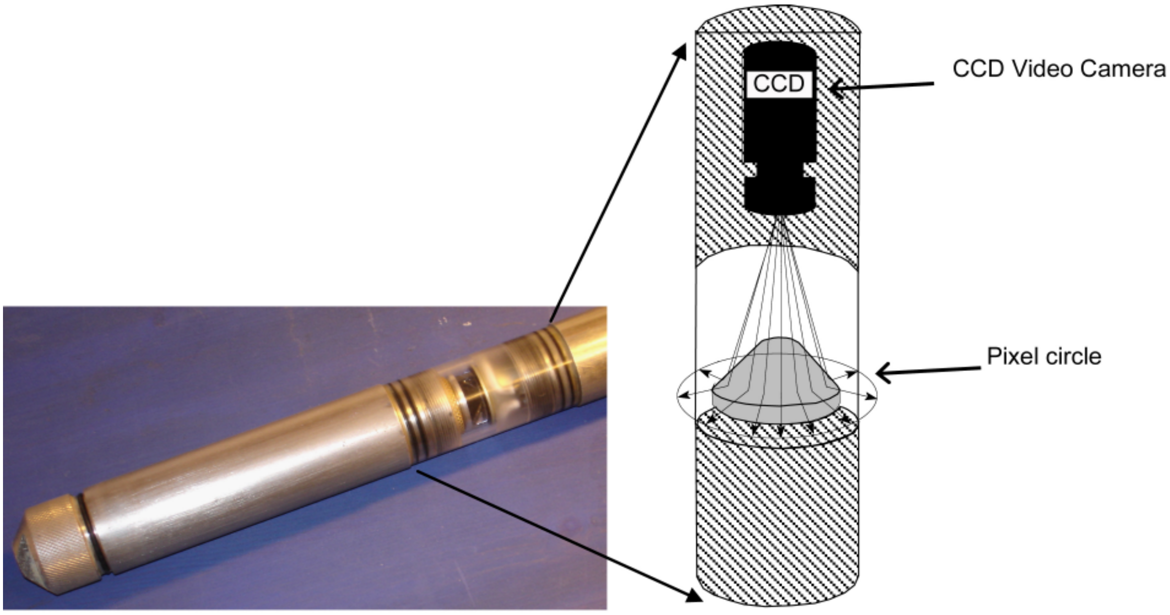


Figure 3-2. *The BIPS-system. To the right a sketch showing the principles of the conical mirror.*

4 Execution

4.1 General

4.1.1 RAMAC Radar

The measurements in KFM02B and KFM08D were carried out with dipole radar antennas with frequencies of 250, 100 and 20 MHz. Measurements were also carried out using the directional antenna, with a central frequency of 60 MHz.

During logging the dipole antennas (transmitter and receiver) were lowered continuously into the borehole and data were recorded on a field computer along the measured interval. The measurement with the directional antenna is made step wise, with a short pause for each measurement occasion. The antennas (transmitter and receiver, both for dipole and directional) are kept at a fixed separation by glass fiber rods according to Table 4-1 and Table 4-2. See also Figure 3-1 and 4-1.

All measurements were performed in accordance with the instructions and guidelines from SKB (internal document MD 252.020). Before the logging operation, the antennas and cable were cleaned according to the internal document SKB MD 600.004.

The functionality of the directional antenna was tested before measurements in the boreholes. This was performed by measurements in the air, where the receiver antenna and the transmitter antenna are placed apart. While transmitting and measuring the receiver antenna is turned around and by that giving the direction from the receiver antenna to the transmitter antenna. The difference in direction is measured by compass and the result difference achieved from the directional antenna was about 0 and 10 degrees for KFM02B and KFM08D respectively. This can be considered to be good, considering the disturbed environment with metallic objects etc at the test site.

For more information on system settings used in the investigations of KFM02B and KFM08D, see Tables 4-1 and 4-2.

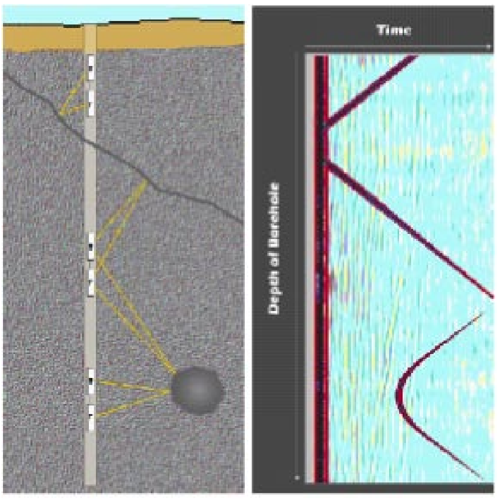


Figure 4-1. *The principle of radar borehole reflection survey (left) and an example of result (right).*

Table 4-1. Radar logging information from KFM02B.

Site:	**Forsmark**	**Logging company:**	**Malå Geoscience AB**	
BH:	**KFM02B**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ Geoscience AB**	
Operator:	**CG**	**Antenna**		
	Directional	**250 MHz**	**100 MHz**	**20 MHz**
Logging date:	2007-02-21	2007-02-21	2007-02-21	2007-02-21
Reference:	T.O.C.	T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):	615	2,424	891	239
Number of samples:	512	619	518	518
Number of stacks:	32	Auto	Auto	Auto
Signal position:	410.5	–0.36	–0.36	–1.42
Logging from (m):	93.4	1.5	2.6	6.25
Logging to (m):	562.9	569.9	570.4	565.95
Trace interval (m):	0.5	0.1	0.2	0.25
Antenna separation (m):	5.73	2.4	3.9	10.05

Table 4-2. Radar logging information from KFM08D.

Site:	**Forsmark**	**Logging company:**	**Malå Geoscience AB**	
BH:	**KFM08D**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ Geoscience AB**	
Operator:	**CG**	**Antenna**		
	Directional	**250 MHz**	**100 MHz**	**20 MHz**
Logging date:	2007-03-09	2007-02-24	2007-02-24	2007-02-24
Reference:	T.O.C.	T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):	615	2,424	891	239
Number of samples:	512	619	518	518
Number of stacks:	32	Auto	Auto	Auto
Signal position:	410.5	–0.36	–0.36	–1.42
Logging from (m):	93.4	61.5	62.6	66.25
Logging to (m):	917.9	930.2	928.6	922.95
Trace interval (m):	0.5	0.1	0.2	0.25
Antenna separation (m):	5.73	2.4	3.9	10.05

4.1.2 BIPS

All measurements were performed in accordance with the instructions and guidelines from SKB (internal document MD 222.006). All cleaning of the probe and cable was performed according to the internal document SKB MD 600.004 before the logging operation.

During the measurement, a pixel circle with a resolution of 360 pixels/circle was used and the digital circles were stored at every 1 mm on a MO-disc in the surface unit. The maximum speed during data collection was 1.5 m/minute.

A gravity sensor was used to measure the orientation of the images in both boreholes.

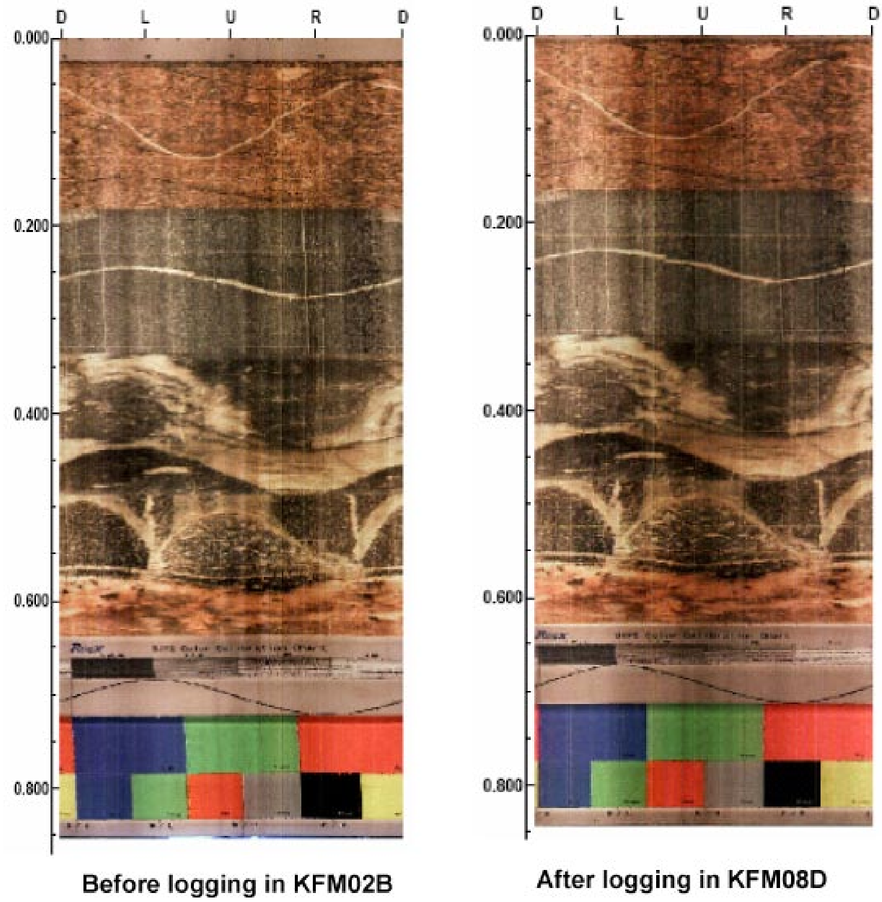


Figure 4-2. Results from logging in the test pipe before and after the logging campaign in February 20th to 25th, 2006. The length scales are not essential in the test measurements.

In order to control the image quality of the system, calibration measurements were performed in a test pipe before logging and after logging, see Figure 4-2. The results showed no difference regarding the colours and focus of the images. Results of the test loggings were included in the delivery of the raw data.

The BIPS logging information is found in the header in the presentations in Appendices 3 and 4.

4.1.3 Length measurements

During logging the length recording for the RAMAC systems is taken care of by a measuring wheel mounted on the cable winch. The logging is measured from TOC (Top of Casing). The length is adjusted to the bottom of casing when visible in the BIPS image.

During the BIPS logging in core drilled boreholes, where the reference marks in the borehole wall is visible on the image, the position where the length mark is visible is marked with scotch tape on the logging cable. During BIPS logging the measured length was adjusted to true length according to length mark visible in the BIPS image. The adjusted true length is marked with red figures in the image plot together with the non-adjusted measured length. The non-adjusted length is marked with black figures as seen in Appendices 3 and 4. The tape marks on the logging cable are then used for controlling the RAMAC measurement.

The experience we have from earlier measurements with dipole antennas in the core-drilled boreholes in Forsmark and Oskarshamn is that the length divergence is less than 100 cm in the deepest parts of a 1,000 metre long borehole. The length divergence is taken into account in the resulting tables in Chapter 5.

4.2 Analyses and interpretation

4.2.1 Radar

The result from radar measurements is most often presented in the form of a radargram where the position of the probes is shown along one axis and the propagation is shown along the other axis. The amplitude of the received signal is shown in the radargram with a grey scale where black color corresponds to the large positive signals and white color to large negative signals. Grey color corresponds to no reflected signals.

The presented data in this report is adjusted for the measurement point of the antennas. The measurement point is defined to be the central point between the transmitter and the receiver antenna.

The two basic patterns to interpret in borehole measurements are point and plane reflectors. In the reflection mode, borehole radar essentially gives a high-resolution image of the rock mass, showing the geometry of plane structures which may or may not, intersect the borehole (contact between layers, thin marker beds, fractures etc) or showing the presence of local features around the borehole (cavities, lenses etc).

The distance to a reflecting object or plane is determined by measuring the difference in arrival time between the direct and the reflected pulse. The basic assumption is that the speed of propagation is the same everywhere.

There are several ways to determine the radar wave propagation velocity. Each of them has advantages and disadvantages. In this project the velocity determination was performed by keeping the transmitter fixed in the borehole while moving the receiver downwards in the borehole. The result is plotted in Figure 4-3, and the calculation shows a velocity of 128 m/μs (metres per microsecond) /1/. The velocity measurement was performed with the 100 MHz antenna.

The visualization of data in Appendices 1 and 2 is made with ReflexWin, a Windows based processing software for filtering and analysis of borehole radar data. The processing steps for the data presented in Appendices 1 and 2 are given in Tables 4-3 and 4-4. The filters applied affect the whole borehole length and are not always suitable in all parts, depending on the geological conditions and conductivity of the borehole fluid. During interpretation further processing can be done, most often in form of bandpass filtering. This filtering can be applied just in parts of the borehole, where needed.

For the interpretation of the intersection angle between the borehole axis and the planes visible on the radargrams the RadinterSKB software has been used. The interpreted intersection points and intersection angles of the detected structures are presented in the Tables 5-3 and 5-4 and are also visible on the radargrams in Appendices 1 and 2.

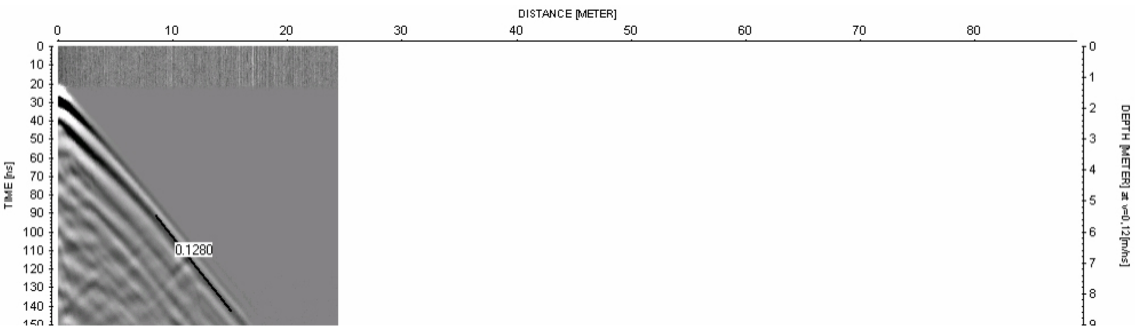


Figure 4-3. *Results from velocity measurements in HFM03.*

Table 4-3. Processing steps for borehole radar data from KFM02B.

Site:	**Forsmark**	**Logging company:**		**MALÅ GeoScience AB**
BH:	**KFM02B**	**Equipment:**		**SKB RAMAC**
Type:	**Directional/Dipole**	**Manufacturer:**		**MALÅ GeoScience AB**
Interpret:	**JG**	**Antenna**		
	Directional	**250 MHz**	**100 MHz**	**20 MHz**
Processing steps	Move start time (41 samples)	Move start time (–14.6)	Move start time (–30.3)	Move start time (–73)
	DC shift (4,190–510)	DC shift (190–230)	DC shift (470–530)	DC shift (1,800–2,000)
	Time gain (start 78 lin 100 exp 5)	Gain (Start 13 lin 2.5 exp 1)	Gain (Start 45 lin 4. 9 exp 0.5)	Gain (Start 122 lin 5.2 exp 0.2)
	(FIR)			

Table 4-4. Processing steps for borehole radar data from KFM08D.

Site:	**Forsmark**	**Logging company:**		**MALÅ GeoScience AB**
BH:	**KFM08D**	**Equipment:**		**SKB RAMAC**
Type:	**Directional/Dipole**	**Manufacturer:**		**MALÅ GeoScience AB**
Interpret:	**JG**	**Antenna**		
	Directional	**250 MHz**	**100 MHz**	**20 MHz**
Processing steps	Move start time (39 samples)	Move start time (–20.6)	Move start time (–34.2)	Move start time (–74.7)
	DC shift (420–510)	DC shift (190–230)	DC shift (470–530)	DC shift (1,800–2,000)
	Time gain (start 68 lin 100 exp 5)	Gain (Start 18 lin 2.5 exp 0.1)	Gain (Start 38 lin 2.9 exp 0.3)	Gain (Start 113 lin 2.5 exp 0.2)
	(FIR)			

4.2.2 BIPS

The visualization of data is made with BDPP, a Windows based processing software for filtering, presentation and analysis of BIPS data. As no fracture mapping of the BIPS image is performed, the raw data was delivered on a CD-ROM together with printable pictures in *.pdf format before the field crew left the investigation site.

The printed results were delivered with measured length, together with adjusted length according to the length marks made on the cable when logging core-drilled boreholes (where the length marks are visible in the BIPS image). For printing of the BIPS images the printing software PDPP from RaaX was used.

4.3 Nonconformities

Due to problems with the directional antenna during the logging campaign in February, the logging of KFM08D was performed in March, 9th 2007.

5 Results

The results from the BIPS measurements in KFM02B and KFM08D were delivered as raw data (*.bip-files) together with printable BIPS pictures in *.pdf format before the field crew left the investigation site. The information of the measurements was inserted in SICADA, and the CD-ROM's stored by SKB.

The RAMAC radar data for KFM02B and KFM08D was delivered as raw data (file format *.rd3 or *.rd5) with corresponding information files (file format *.rad) on CD-ROM's to SKB before the field crew left the investigation site, whereas the data processing steps and results are presented in this report. Relevant information, including the interpretation presented in this report, was inserted into the SKB database SICADA.

5.1 RAMAC logging

The results of the interpretation of the radar measurements are presented in Tables 5-1 to 5-7. Radar data are also visualized in Appendices 1 and 2. It should be remembered that the images in Appendices 1 and 2 are a composite picture of all events 360 degrees around the borehole, and do not reflect the orientation of the structures.

Only the larger clearly visible structures are interpreted in RadinterSKB. An overview of the boreholes is given in Figure 5-1. Differences in data quality can be observed along the borehole, see for instance data from KFM02B, 400 to 500 m, where the penetration is quite bad, most probably due to electrical conductive conditions.

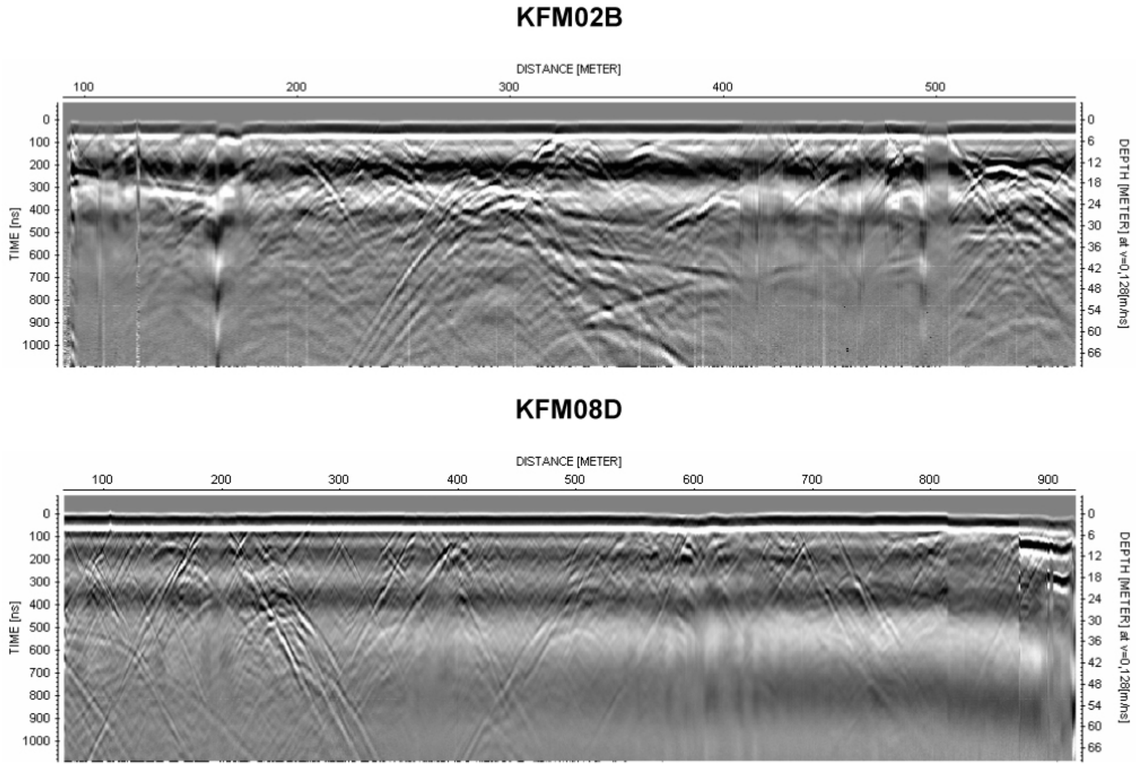


Figure 5-1. *An overview (20 MHz data) of the radar data for the boreholes KFM02B and KFM08D.*

A detail from KFM08D is shown in Figure 5-2. This strong reflector is identified with the directional antenna and does not show up that clear in the dipole data shown in Appendix 2. The reflector is denoted "235" in Table 5-2 and intersects the borehole with an angle of 3 degrees.

A number of minor structures also exist, as indicated in Appendices 1 and 2. Often clusters of structures can be noticed, but often located so close to each other that it is impossible to distinguish one from the other. Larger structures parallel to the borehole, if present, are also indicated in Appendices 1 and 2. It should also be pointed out that an interpreted reflector always results in an intersection with the borehole (unless the reflector is strictly parallel to the hole). However, sometimes this intersection point is localized outside the range of the borehole.

The data quality from KFM02B and KFM08D (as seen in Appendices 1 and 2) is satisfying to good, but in some parts of lower quality due to more electrical conductive conditions. An electrical conductive environment causes an attenuation of the radar wave, which in turn decreases the penetration. This conductive environment of course also reduces the possibility to distinguish and interpret possible structures in the rock which otherwise could give a reflection.

This effect is also seen in the directional antenna, which makes it more difficult to interpret the direction to the identified structures.

As also seen in Appendices 1 and 2, the resolution and penetration of the radar waves depend on the antenna frequency used. Low antenna frequency gives less resolution but better penetration compared to a higher frequency. It can probably be concluded that structures that are identified with all three antenna frequencies are quite significant.

In Tables 5-1 and 5-2 the distribution of identified structures along the borehole are listed.

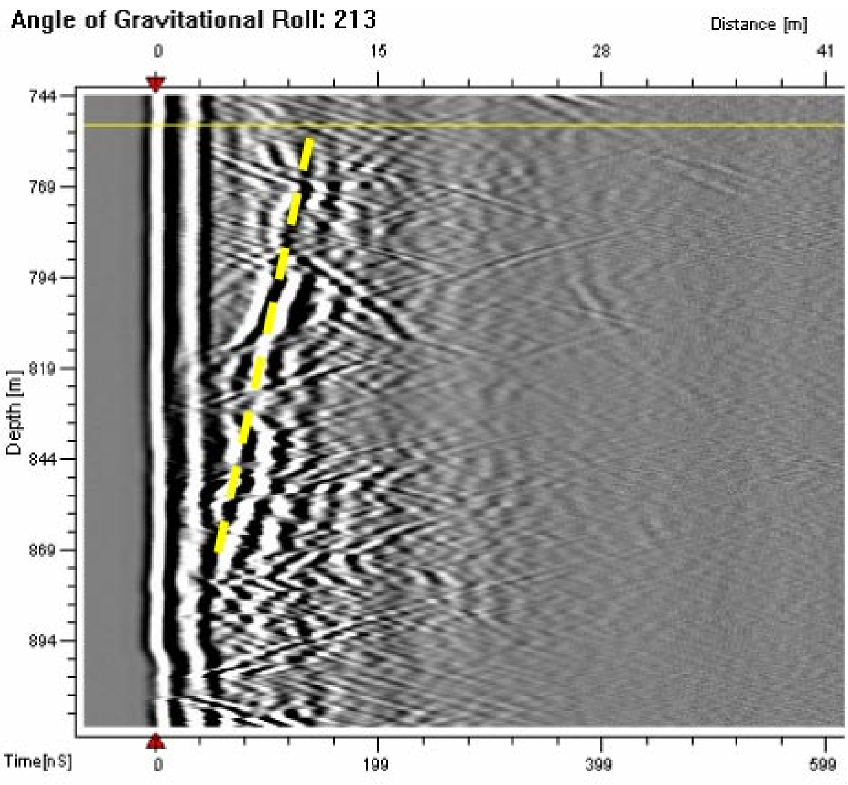


Figure 5-2. *A detail from KFM08D (directional antenna) showing a strong sub-parallel structure (indicated by yellow dashed line) near the bottom of the borehole. The structureis denoted "235" in Table 5-2 and intersects the borehole with an angle of 3 degrees.*

Table 5-1. Identified structures as a function of borehole intersection length in KFM02B.

Length (m)	No. of structures
–50	1
50–100	2
100–150	12
150–200	22
200–250	9
250–300	13
300–350	9
350–400	9
400–450	10
450–500	8
500–550	4
550–	6

Table 5-2. Identified structures as a function of borehole intersection length in KFM08D.

Length (m)	No. of structures
–50	6
50–100	17
100–150	24
150–200	16
200–250	11
250–300	12
300–350	8
350–400	12
400–450	15
450–500	10
500–550	14
550–600	12
600–650	11
650–700	13
700–750	24
750–800	14
800–850	15
850–900	9
900–	8

Tables 5-3 and 5-4 summarises the interpretation of radar data from KFM02B and KFM08D. In the tables the borehole length and intersection angle to the identified structures are listed.

As seen, some radar reflectors in Tables 5-3 and 5-4 are marked with ±, which indicates an uncertainty in the interpretation of direction. The direction can in these cases be ± 180 degrees. The direction to the object (the plane) is defined in Figure 5-3. This direction and the intersection angle are recalculated to strike and dip, also given in the tables below. The plane strike is the angle between the line of the plane's intersection with the surface and the Magnetic North direction. A strike of 0 degrees implies a dip to the east while a strike of 180 degrees implies a dip to the west (right-hand rule). The strike is measured clockwise and can vary from 0 to 359 degrees. The dip of the plane is the angle between the ground surface and the plane, and can vary from 0 to 90 degrees.

Observe that the interpretation of an undulating structure can result in several different angles and different intersection lengths. An example of this phenomenon is seen in Table 5-3 and Appendix 1: e.g. the reflectors named 35 and 35x most likely originates from the same geological structure.

Observe, that the reflectors denoted 221 and 222 in Table 5-4 and Appendix 4 probably originates from the boreholes KFM08C and HFM22, which both are located close to KFM08D.

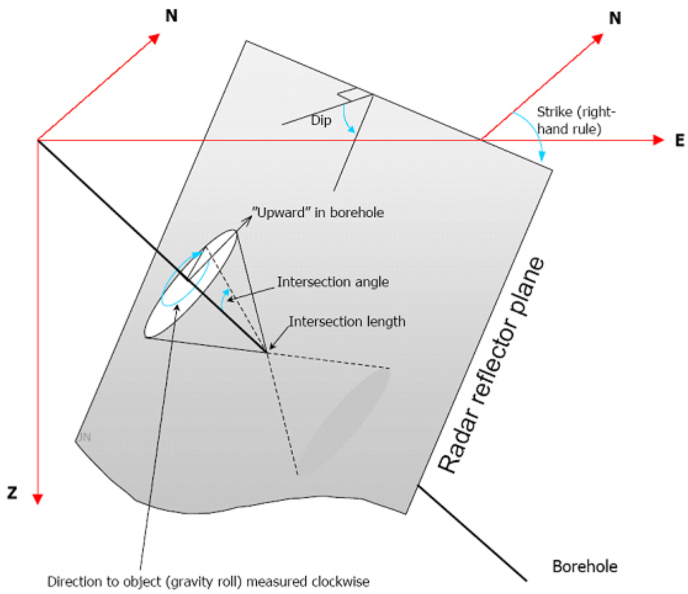


Figure 5-3. *Definition of the direction to a reflector (gravity roll) as presented in Tables 5-3 and 5-4.*

Table 5-3. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz in borehole KFM02B.

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM02B
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
99	–523.9	2					
5	–62.7	6	33	88	252		
61	82.5	2					
3	97.5	73					
4	100.3	67					
1	101.1	60					
2	103.0	74					
96	110.2	65					
7	112.5	80	75 ±	19	84	12	345
6	112.8	61					
8	119.6	63					
9	123.1	70					
10	130.5	69					
11	134.4	73					
13	136.5	68					
92	137.6	76					
15	152.0	74					
12	152.5	24					
14	153.7	62					
16	157.1	57					
17	158.8	65	153	12	172		
18	163.0	66					
20	165.5	63					
19	167.5	56					
22	169.5	79					
97	170.9	80					
26	172.4	72	243 ±	16	315	24	82
23	175.7	82					
24	177.0	68					
21	179.8	57					
41	186.0	18					
27	189.0	55					
40	190.6	22					
91	194.9	46					
29	197.0	51					
33	197.3	57					
28	198.1	82					
60	198.7	4	252	83	297		
30	202.4	82					
34	205.2	72					
31	208.0	78					
32	220.7	66					
35	226.1	69	0 ±	33	41	12	221
35x	228.2	50					
36	236.0	75					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM02B
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
90	237.3	73					
37	243.3	76	216 ±	13	282	30	66
39	258.8	57	102 ±	29	125	33	338
38	259.4	45					
42	261.4	38					
48	272.0	16	306 ±	81	351	69	167
93	273.8	67					
44	274.1	53	105	37	133		
47	274.7	13					
43	279.0	68	120 ±	19	136	29	357
46	280.0	14	279	78	325		
104	292.2	61	60 ±	35	89	25	300
45	293.1	76					
49x	298.9	54	231 ±	31	286	43	84
49	299.2	69					
50	304.6	55					
61x	304.6	9					
89	323.1	69					
53	325.5	49					
51	326.7	26					
52	331.0	36					
59	343.5	37	147	46	185		
57	347.3	22					
58	349.9	44					
54	350.2	54					
55	364.1	20					
65	371.1	15	354	84	38		
56	371.7	20					
64	374.1	46					
101	376.7	42					
62	386.1	18					
63	397.0	15	348	85	31		
63x	390.5	19					
66	410.5	78					
67	414.0	81					
70	419.6	66					
69	421.1	71	273 ±	22	344	21	109
71	425.3	80					
68	427.3	19					
72	427.7	71					
73	429.3	77	246 ±	13	336	20	83
74	448.8	35	300	60	350		
75	449.7	63					
103	452.3	62	144 ±	20	172	37	17
76	470.0	74	108 ±	15	110	19	4
88	471.0	81					
79	481.1	77					
87	483.2	37					

RADINTER MODEL INFORMATION (Directional and dipole antennas)							
Site: Forsmark							
Borehole name: KFM02B							
Nominal velocity (m/μs): 128.0							
Name	**Intersection length**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
77	488.0	58					
86	491.2	61					
78	499.2	80	264 ±	17	347	17	91
80	506.7	67					
85	539.2	59					
81	539.5	54	324	45	15		
83	547.1	51					
82	553.0	51					
84	558.9	65					
102	562.6	61	48 ±	36	81	22	291
98	584.3	52	150 ±	30	186	48	20
95	608.1	15					
100	635.8	12					

Table 5-4. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz in borehole KFM08D.

RADINTER MODEL INFORMATION (Directional and dipole antennas)							
Site: Forsmark							
Borehole name: KFM08D							
Nominal velocity (m/μs): 128.0							
Name	**Intersection length**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
222	–289.4	6	57 ±	76	58	66	64
223	–46.1	15					
221	–27.5	29					
231	–21.6	37					
215	30.9	35					
214	35.9	54					
213	52.1	54					
222x	54.0	38					
10	57.7	34					
1x	63.6	27					
1	67.8	46					
2	74.6	66					
223x	65.2	28					
3	75.7	64					
4	77.7	61					
5	81.4	56	186	4	124		
6	82.6	56					
212	87.6	63					
211	94.4	53					
210	97.9	51					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM08D
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
7	98.1	46					
9	98.8	57	288 ±	54	140	38	232
8	99.6	46					
11	106.8	58					
219	107.2	61					
14	108.1	61					
15	109.3	52					
17	111.0	55					
19	112.8	49	129 ±	34	263	71	144
18	113.2	40					
16	114.8	61					
20	116.1	60					
26	122.1	55					
218	122.1	58					
21x	123.2	25					
22	123.6	43					
21	123.9	33	120 ±	47	270	79	131
23	125.4	63	351 ±	62	174	11	201
24	131.0	61					
25	133.3	62					
217	135.7	35					
28x	140.1	48	114	42	252		
209	141.3	38					
216	142.4	27					
12	143.9	8					
27	147.3	53					
28	148.8	31					
29	152.4	43	339 ±	82	163	18	300
208	152.8	54					
31	152.3	60					
30	155.6	48					
32	169.1	53					
33	172.6	47					
34	177.8	34					
13	185.9	6					
35	187.1	29	186	25	10		
36	187.3	55	111 ±	40	243	60	136
37	190.1	36					
36x	192.3	32					
230	195.5	44					
40	198.7	54					
38	198.9	31					
39	199.1	45					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM08D
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
42	204.6	24	246 ±	58	82	85	236
41	205.4	32					
42x	210.7	34					
43	214.4	40					
44	219.4	37					
45	227.1	33					
47	231.6	48					
48	233.9	52					
46	237.8	32	132	39	279		
49	240.0	51					
52	249.9	65					
50	252.7	35					
51	254.7	41					
53	255.3	64					
54	260.7	33					
237	265.1	36					
55	267.8	41					
207	280.8	29					
233	281.4	51					
56xx	282.4	40					
56	283.5	33	297	76	128		
57	286.8	51					
56x	290.6	22					
58x	313.5	44					
58xx	315.7	28					
58	317.3	32	285	70	119		
59	321.4	39					
60	324.8	41					
61	329.4	39					
62	333.5	38					
206	338.1	64					
65	359.8	48					
63	360.1	34					
64	362.3	33	117	48	266		
66	372.3	51					
68	375.4	56					
73	377.4	55	207 ±	16	93	71	193
67	378.9	36					
69	381.2	54					
70	385.3	46	165 ±	12	300	78	166
72	387.4	48					
75	392.4	50					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM08D
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
71	393.7	35					
74	400.6	40	30 ±	82	198	23	67
77	402.0	39					
220	403.4	24					
78	407.6	39					
79	414.7	41					
76	420.6	26					
159	420.9	4	54	72	54		
205	430.6	49					
80	431.1	37					
85	431.1	51	105 ±	46	243	62	126
82	434.4	52					
76x	435.5	18					
84	441.2	41					
81	442.8	46					
83	449.8	47					
86	467.8	65					
89	468.4	32					
87	472.2	72					
90	474.8	63					
88	476.9	57					
91	477.4	45					
92	482.9	60					
204	493.5	44					
96	494.6	43					
93	498.0	41					
94	501.4	44					
95	504.3	45					
97	507.8	47					
98	517.2	45					
203	522.3	39	150 ±	24	286	82	154
99	525.9	55					
100	528.0	52					
224	531.5	35					
105	532.9	48					
101	536.2	35					
102	537.4	37					
103	546.4	47					
104	547.4	40	177 ±	17	347	89	353
225	548.4	34					
111	554.3	42					
202	556.6	49					
106	560.3	48					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM08D
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
107	561.7	38					
108	563.9	47					
201	565.8	48					
159x	566.6	7					
110	569.0	85					
109	571.4	50					
115	582.7	51					
226	597.7	62					
113	597.8	53					
112	605.2	53	171 ±	8	215	69	171
114	610.0	60					
117	617.6	52					
119	621.0	49					
116	623.1	51					
121	632.4	34					
118	632.5	21	231 ±	45	73	89	219
123	635.2	50					
122	643.9	38					
120x	647.0	22					
120	649.6	19	240 ±	55	76	89	229
124	655.7	47					
126	656.7	58	333	67	161		
125	661.3	47					
127	665.7	48					
229	666.9	32					
200	671.7	45					
128	673.5	48					
130	675.7	49					
129	676.6	48	150	20	268		
131	678.9	48					
132	685.2	46	12	84	185		
133	686.2	39					
134	695.5	44					
136	700.6	41					
199	707.0	40					
135	708.1	49	3	80	178		
137	711.2	47					
140	712.3	36					
138	716.7	42					
141	720.2	32					
145	725.8	45					
234	726.6	37					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM08D
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
144	734.6	26					
143	734.7	35					
198	731.3	40					
232	737.0	38					
197	737.4	42					
142	737.9	19					
147	739.6	44					
196	739.2	41					
149	740.9	44	210	21	80		
146x	744.4	25					
146	745.7	17					
139	746.7	13					
150	747.0	42					
148	748.6	41					
151	749.8	35					
236	751.0	17	0 ±	68	356	34	356
152	751.7	42					
153	755.4	41					
154	759.3	47					
155	767.0	46	201 ±	13	94	77	189
195	772.1	52					
157	776.1	51					
158	777.9	52					
160	783.9	43					
161	787.4	42					
162	785.0	46					
164	792.4	43					
163	797.1	40					
169	798.3	50					
165	800.5	47					
170	803.9	50					
166	806.8	22					
168	806.2	62					
167	810.3	56					
194	816.0	62					
171	819.5	44					
173	822.6	65					
174	833.1	49	159	13	259		
176	831.5	46					
175x	834.1	38					
177	839.9	44					
175	841.3	24					
178	847.5	41	78 ±	63	227	50	112

RADINTER MODEL INFORMATION (Directional and dipole antennas)							
Site: Forsmark Borehole name: KFM08D Nominal velocity (m/μs): 128.0							
Name	**Intersection length**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
179	847.9	45					
181	859.1	47					
180	860.7	59					
182	862.2	69					
228	886.5	43					
183	870.8	57					
184	874.1	24					
193	886.2	58					
185	892.1	74					
192	898.9	45					
190	900.0	62					
186	904.8	52					
187	906.1	37					
188	908.8	47	147 ±	21	255	76	154
189	909.7	52					
227	912.0	55					
191	924.0	48					
235	966.0	3	213 ±	55	38	61	34

In Appendices 1 and 2, the amplitude of the first arrival is plotted against the borehole length, for the 250 MHz dipole antennas. The amplitude variation along the borehole indicates changes of the electrical conductivity of the rock volume surrounding the borehole. A decrease in this amplitude may indicate fracture zones, clay or rock volumes with increased water content. i.e. increased electric conductivity. The borehole length intervals showing decreased amplitude are listed in Tables 5-5 and 5-6.

Table 5-5. Borehole length intervals in KFM02B with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
100–105	415
110–115	420–430
165–170	450
195–205	460–475
240–245	485–490
325	495–505

Table 5-6. Borehole length intervals in KFM08D with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
185–195	580–600
200–205	605
285	620–635
360	645
395	890–895
545	905–910
565–580	925–930

Finally, the structures considered as the most important (clear in the radargram, identified with several antenna frequencies, stretching out far from the borehole wall etc) are listed in Table 5-7 below.

Observe that it can be very difficult to classify different structures in an objective manner along a borehole. This is due to the fact that the water quality (the conductivity) amongst other parameters varies along the borehole length. This variation affects the results of the radar logging, by for instance attenuating the radar waves differently. Also the intersection angle of the identified structures affects the amplitude on the resulting radargram. A small angle will most often cause larger amplitude than a large angle, and by that a more clear structure.

5.2 BIPS logging

The BIPS pictures are presented in Appendices 3 and 4.

To get the best possible length accuracy, the BIPS images are adjusted to the reference marks on the logging cable. Additionally the marks on the borehole wall created by the drill rig in are visible on the BIPS screen. The recorded length is adjusted to these visible marks.

In order to control the quality of the system, calibration measurements were performed in a test pipe before logging the first borehole and after logging of the last borehole in the campaign. The resulting images displayed no difference regarding the colours and focus of the images. The results of the test logging were included in the delivery of the field data and are also presented in Figure 4-2 in this report. Values for the inclination and azimuth of the boreholes, presented in this report, are only preliminary.

In total three logging runs have been performed in KFM02B. The two first runs were conducted in order to provide BIPS images for the geologists to speed up the core logging. In KFM08D the first run was heavily effectedby mud in the borehole. After a cleaning process in the borehole a second run was conducted, which resulted in improved images.

Table 5-7. Some important structures in KFM02B and KFM08D.

Borehole	KFM02B	KFM08D
Structures	1, 6, 35, 37, 40, 41, 43, 46, 48, 49, 49x, 63, 63x, 65, 69, 74, 76, 90 and 100	5, 8, 9, 15, 16, 21, 28, 28x, 36, 36x, 36xx, 38, 42, 42x, 51, 56, 56x, 56xx, 58, 58x, 67, 76, 76x, 112, 112x, 129, 130, 135, 135x, 140, 186, 174, 221, 222, 224, 225 227, 228, 230, 231, 235 and 236

To get a better understanding of the quality of the orientation of the images, a comparison between the probe orientation in two runs is shown in Table 5-8 and 5-9, utilizing features that can be clearly identified on the plots from both runs. The table shows examples of differences in the orientation of the probe ("Gravity Roll") between the two runs, and gives an idea of the uncertainties involved. The direction values in the table are measured on a high-resolution plot from the lowermost point of the borehole wall to features visible in the two individual runs. The main sources to uncertainties are the centralizers attached to the probe, probe rotation during measurement, software centralizing of the CCD unit in the probe, operator picking of probe orientation during measurement.

Table 5-8. Differences in probe orientation between two runs in KFM02B.

Length (m)	Run 1 (°)	Run 2 (°)	Difference (°)
251.4	171.4	176.2	4.8
264.5	168.1	169.2	1.1
290.5	343.4	340.5	–2.9
304.2	185.3	192.3	7.0
309.7	202.2	217.3	15.1
333.4	296.4	301.4	5.0
352.8	332.5	340.5	8.0
370.7	93.1	101.3	8.2
391.5	196.9	215.3	18.4
407.3	281.4	286.4	5.0
416.1	255.3	259.4	4.1
434.6	72.1	76.1	4.1
449.5	224.4	217.3	–7.1

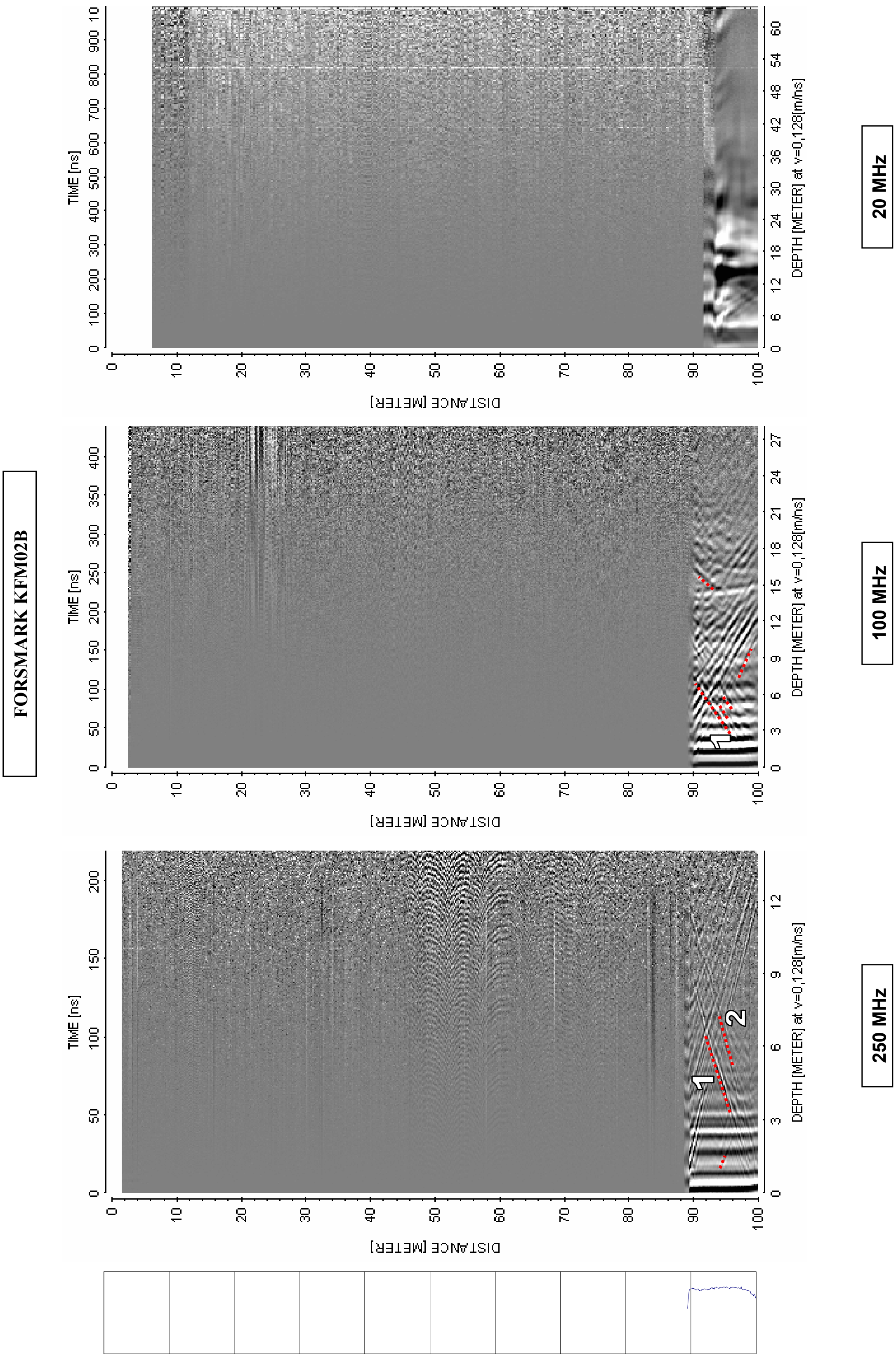
Table 5-9. Differences in probe orientation between two runs in KFM08D.

Length (m)	Run 1 (°)	Run 2 (°)	Difference (°)
62.3	54.7	57.9	3.2
75.4	118.2	113.5	–4.7
98.8	177.6	178.3	0.7
125.3	227.3	225.3	–2.0
149.5	152.2	148.2	–4.0
175.2	167.6	170.2	2.7
202.3	179.6	180.9	1.3
243.6	168.9	169.3	0.4
279.1	151.5	150.2	–1.3

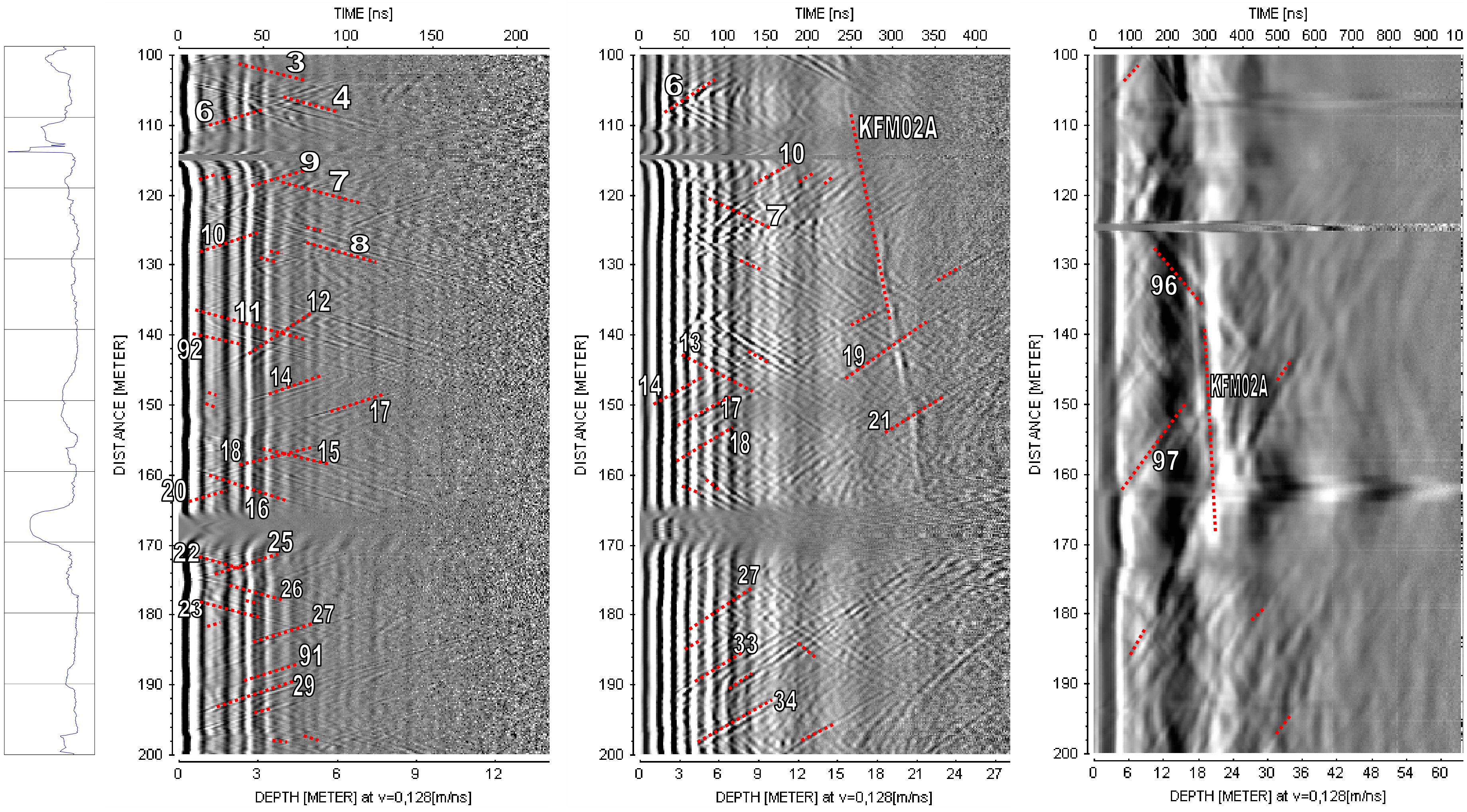
References

/1/ **Gustafsson C, Nilsson P, 2003.** Geophysical Radar and BIPS logging in borehole HFM01, HFM02, HFM03 and the percussion drilled part of KFM01A. SKB P-03-39. Svensk Kärnbränslehantering AB.

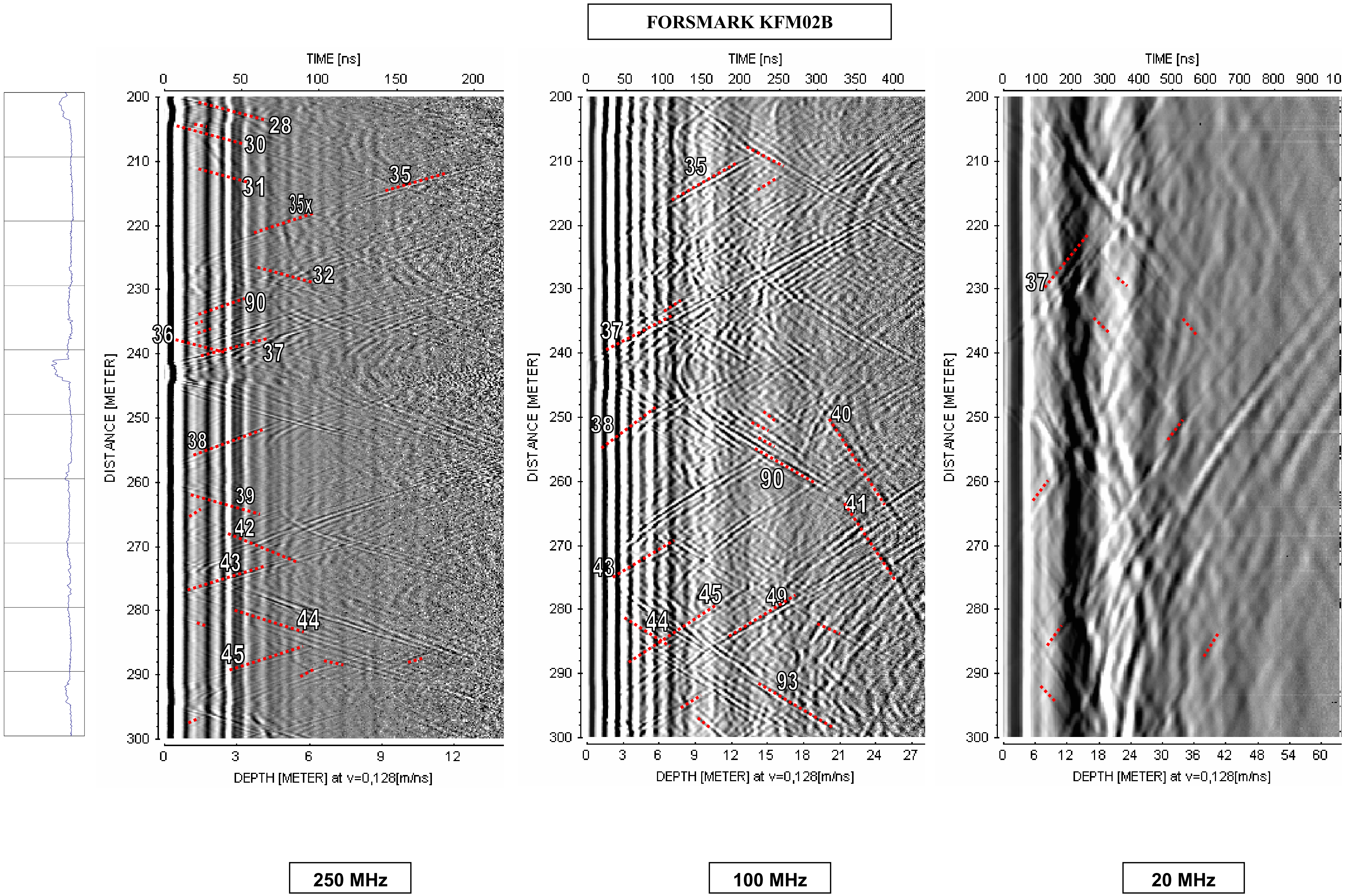
Radar logging in KFM02B. 0 to 569 m. Dipole antennas 250, 100 and 20 MHz



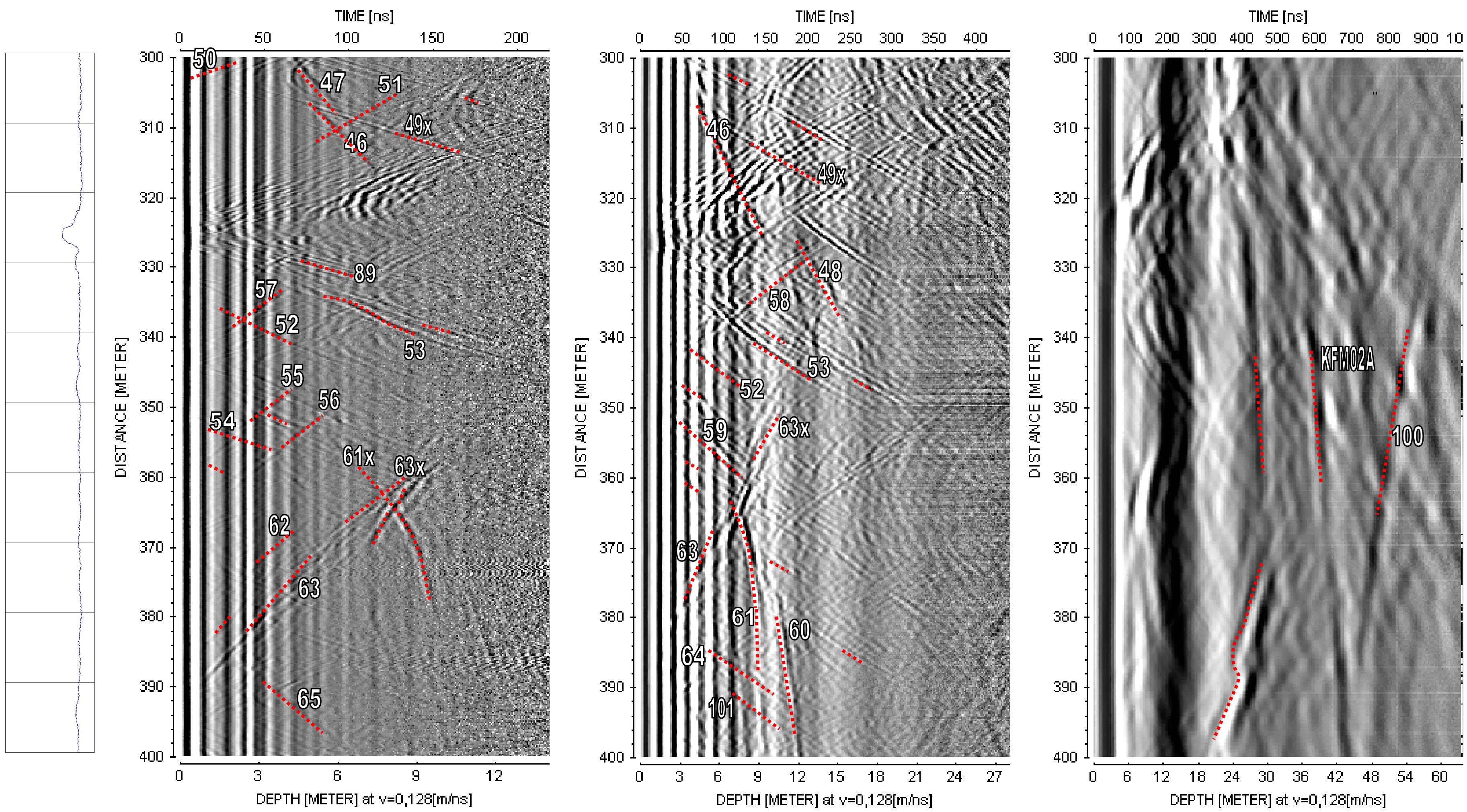
FORSMARK KFM02B



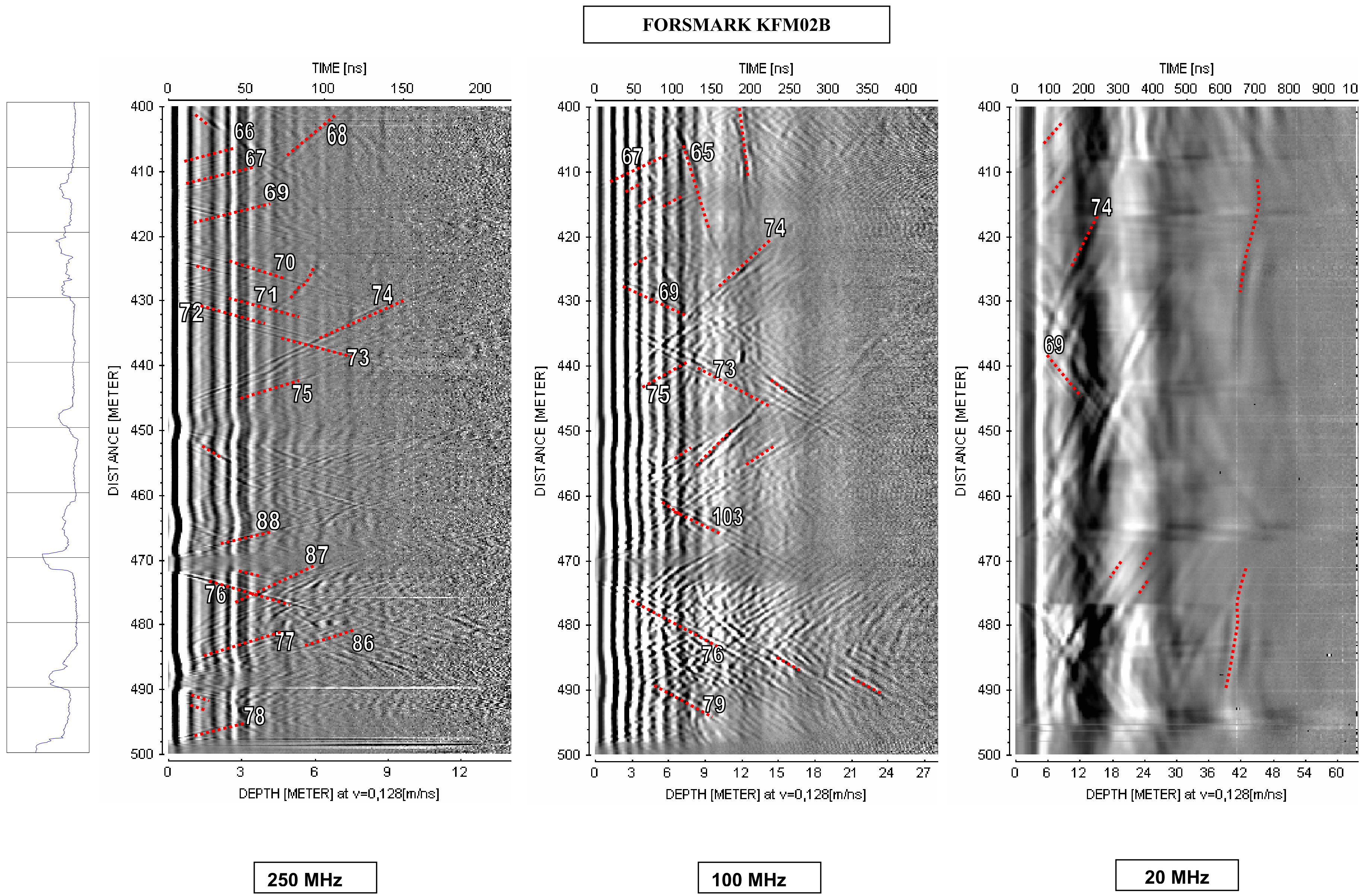
250 MHz **100 MHz** **20 MHz**


FORSMARK KFM02B
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
250 MHz
100 MHz
20 MHz

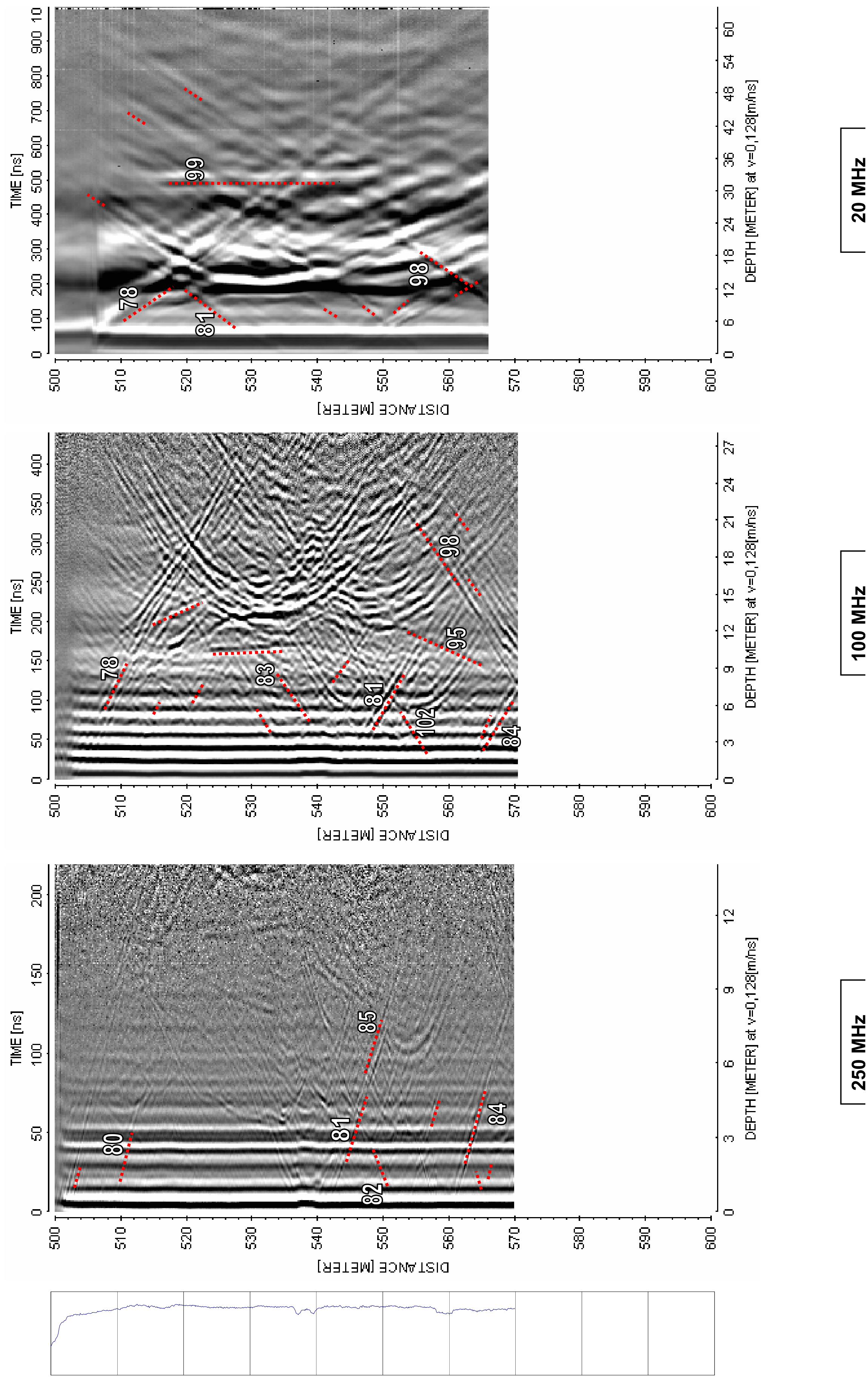
FORSMARK KFM02B



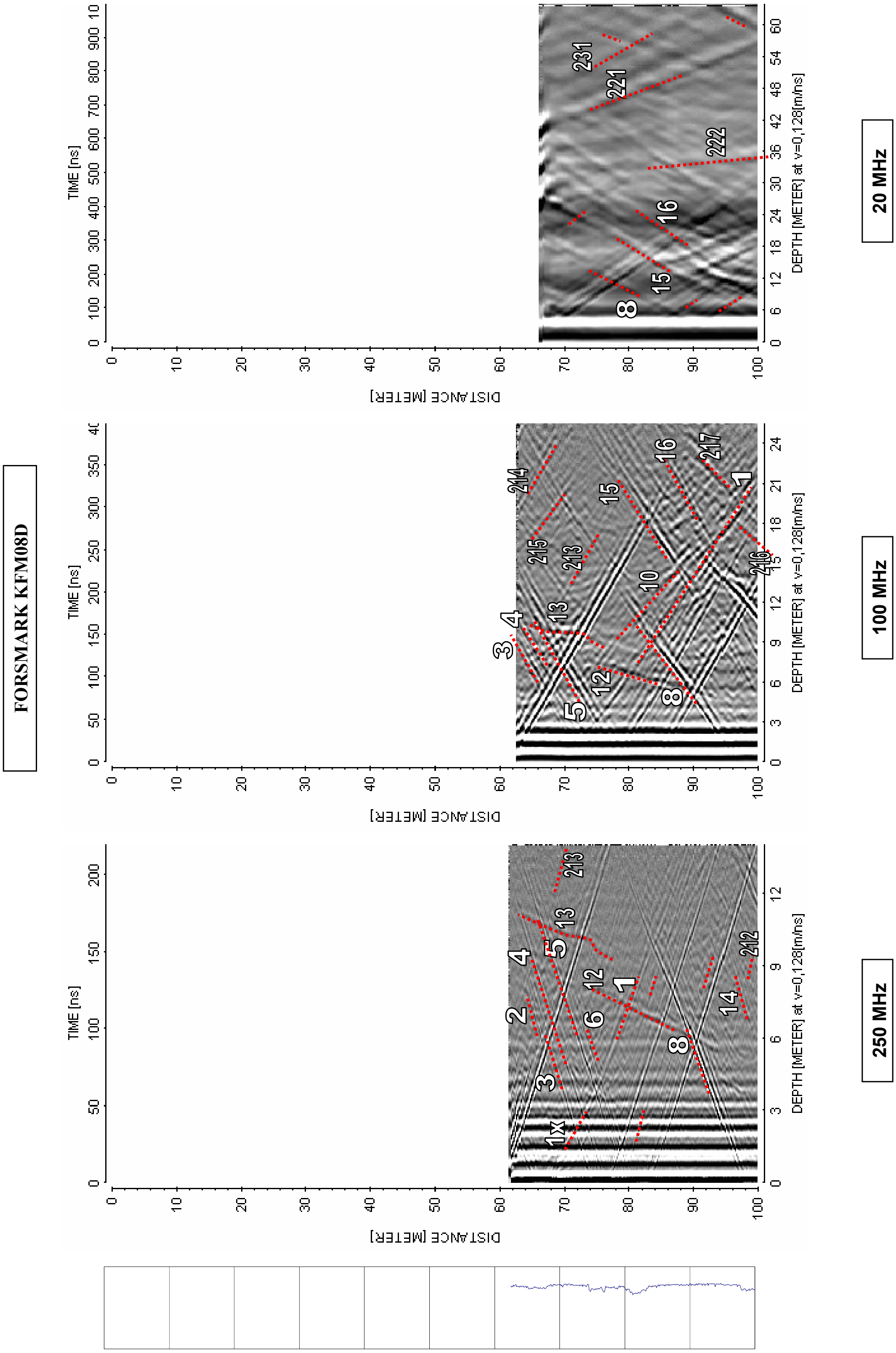
250 MHz **100 MHz** **20 MHz**

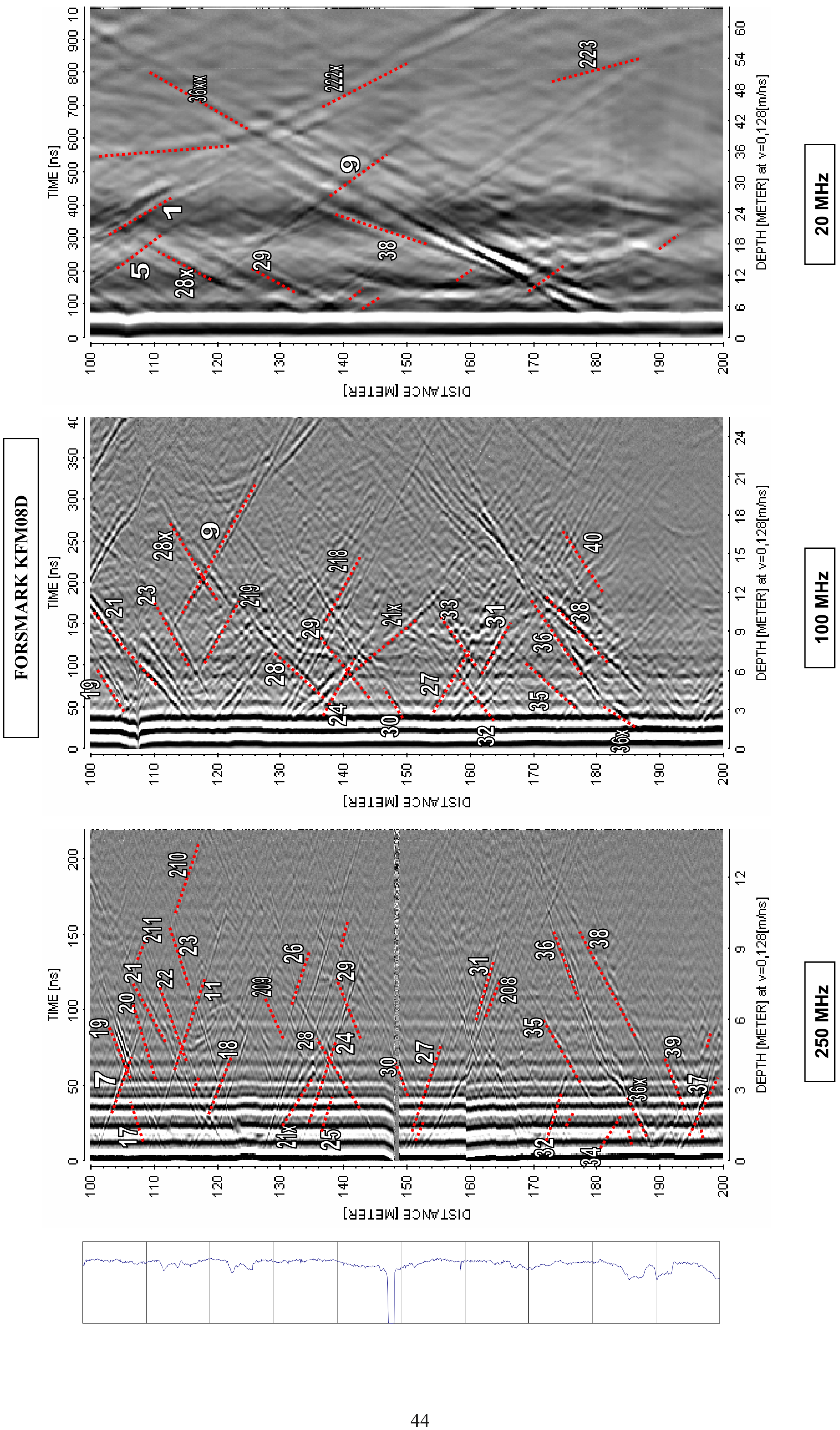

FORSMARK KFM02B
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
66
67
68
69
70
71
72
73
74
75
88
87
76
77
86
78
65
103
79
250 MHz
100 MHz
20 MHz

FORSMARK KFM02B

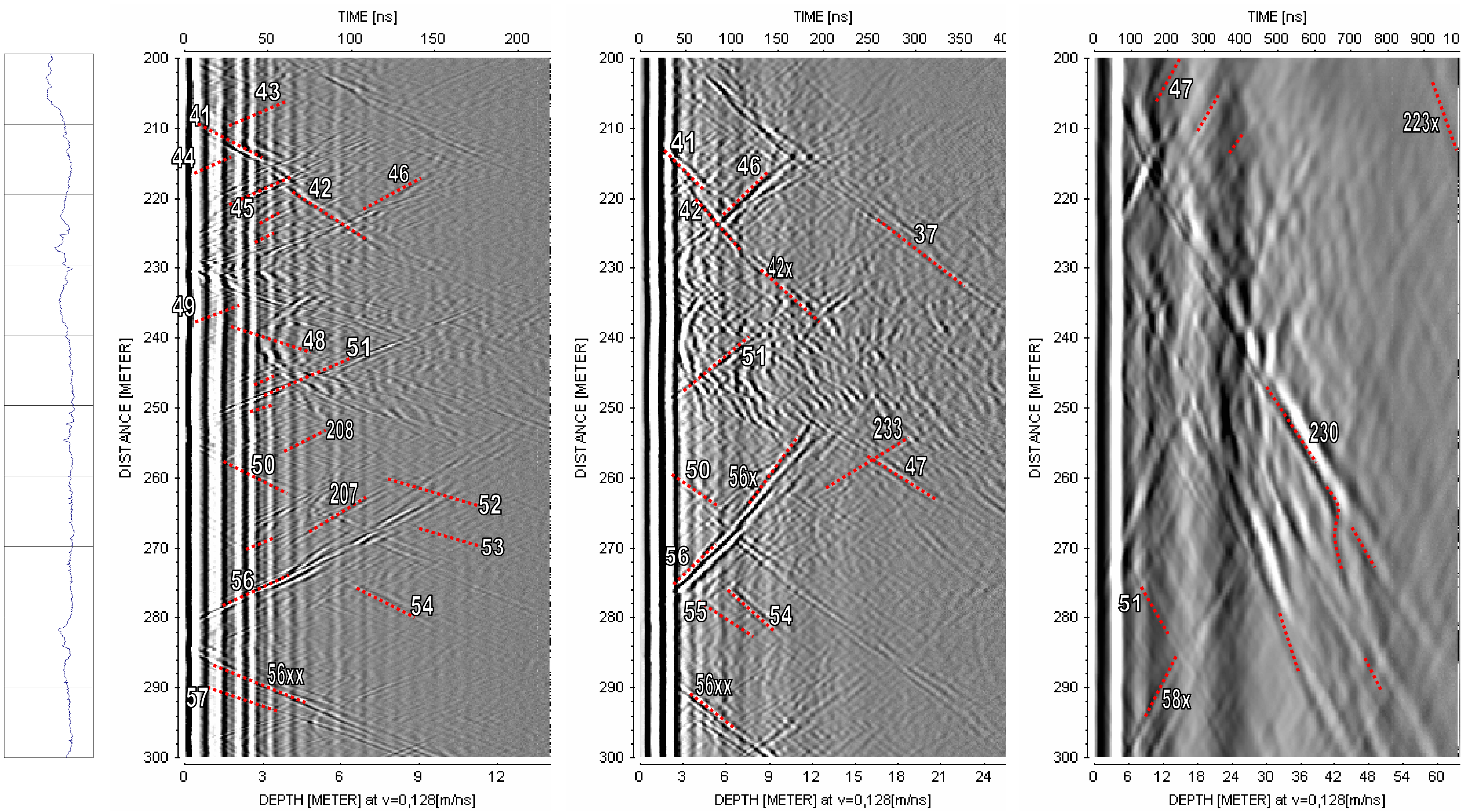


Radar logging in KFM08D. 60 to 927 m. Dipole antennas 250, 100 and 20 MHz




FORSMARK KFM08D
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]

FORSMARK KFM08D

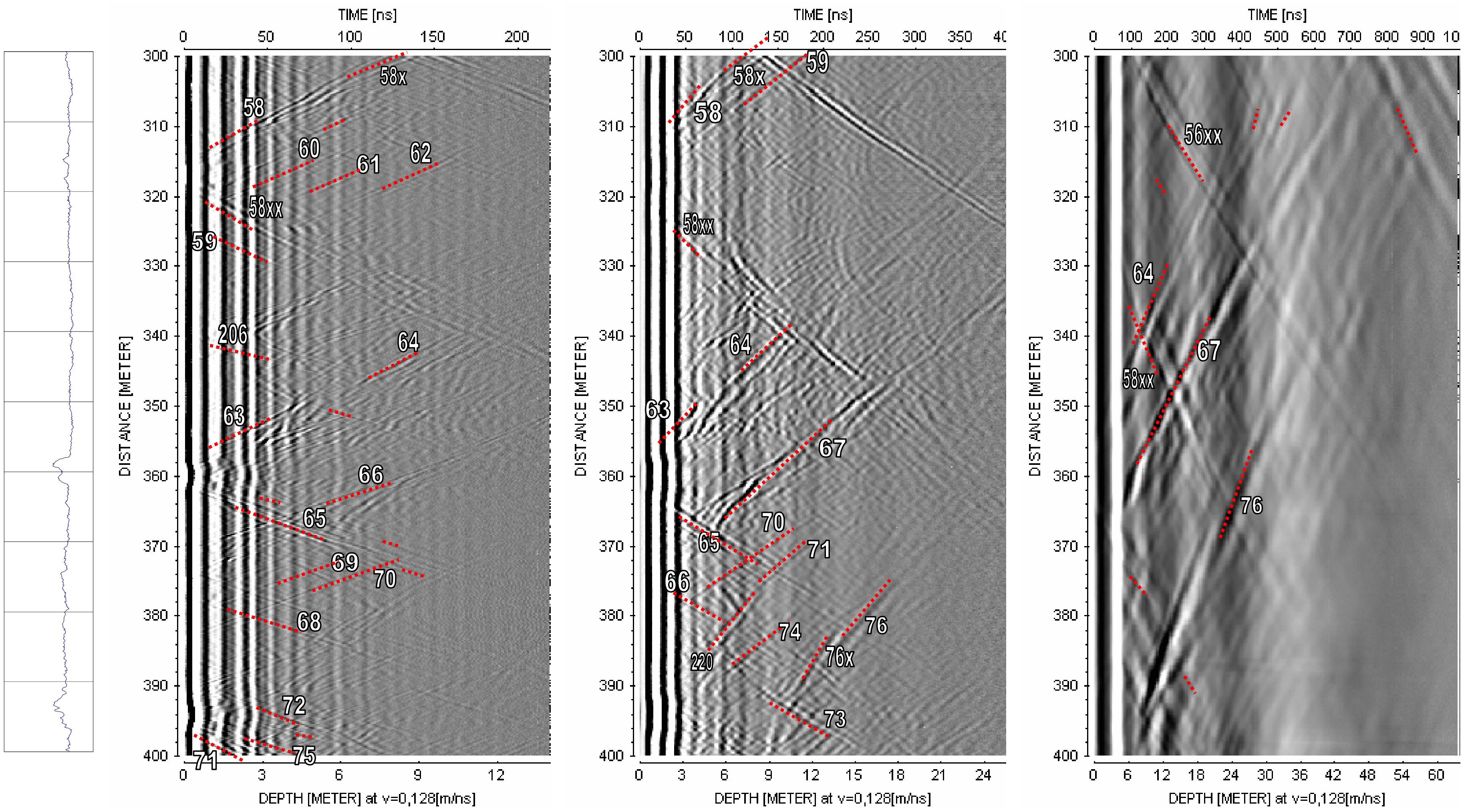


250 MHz

100 MHz

20 MHz

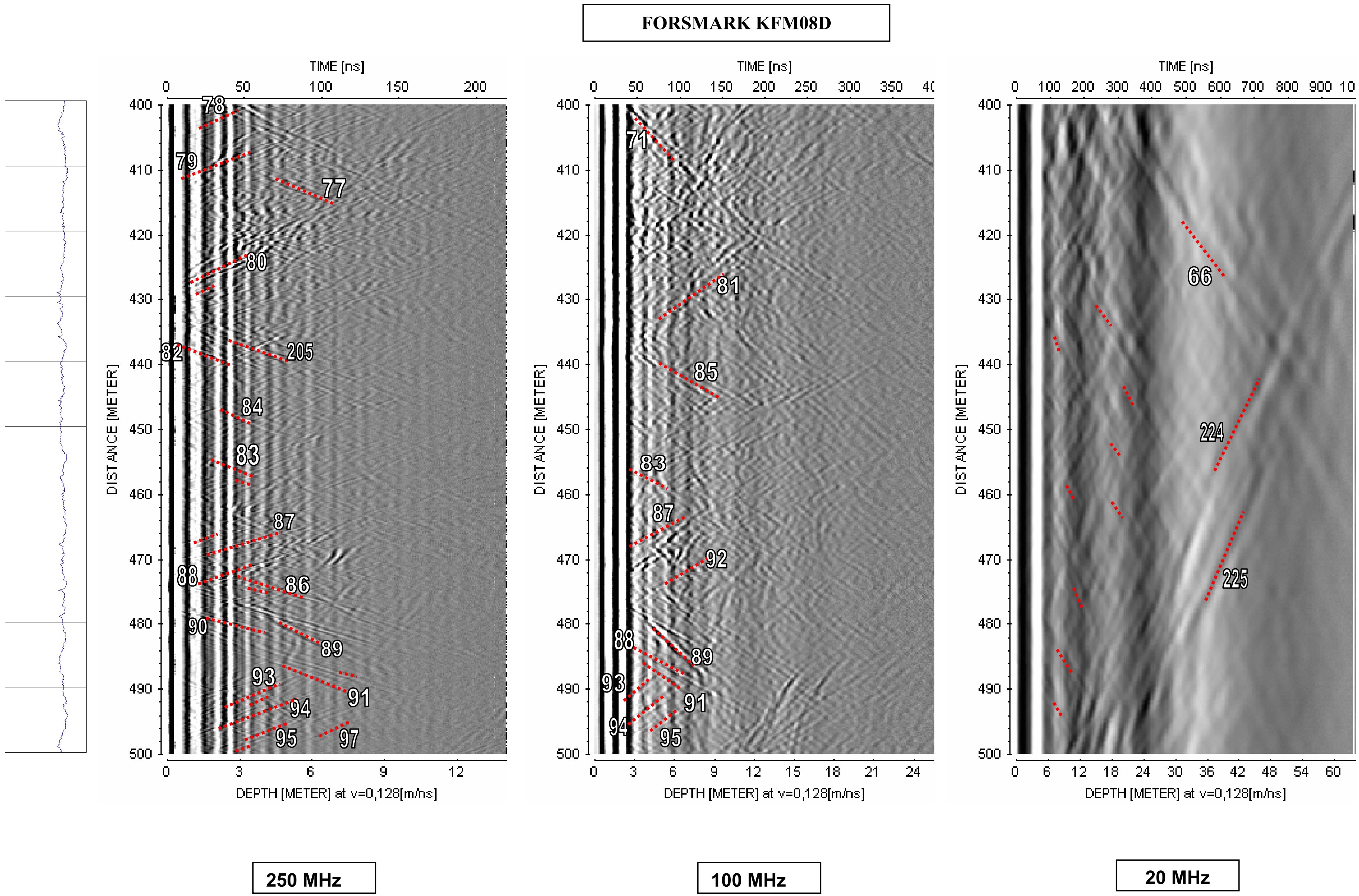
FORSMARK KFM08D



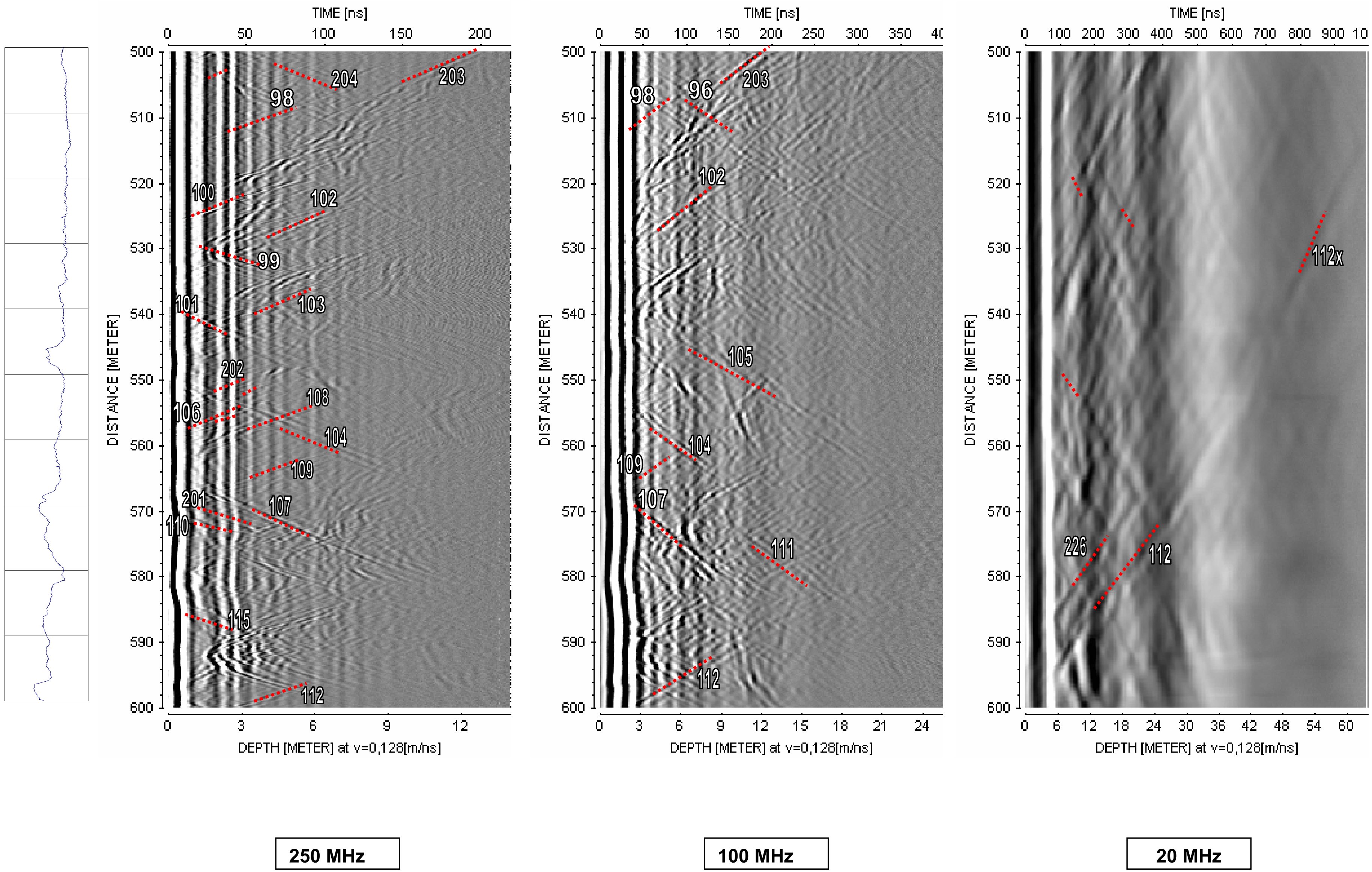
250 MHz

100 MHz

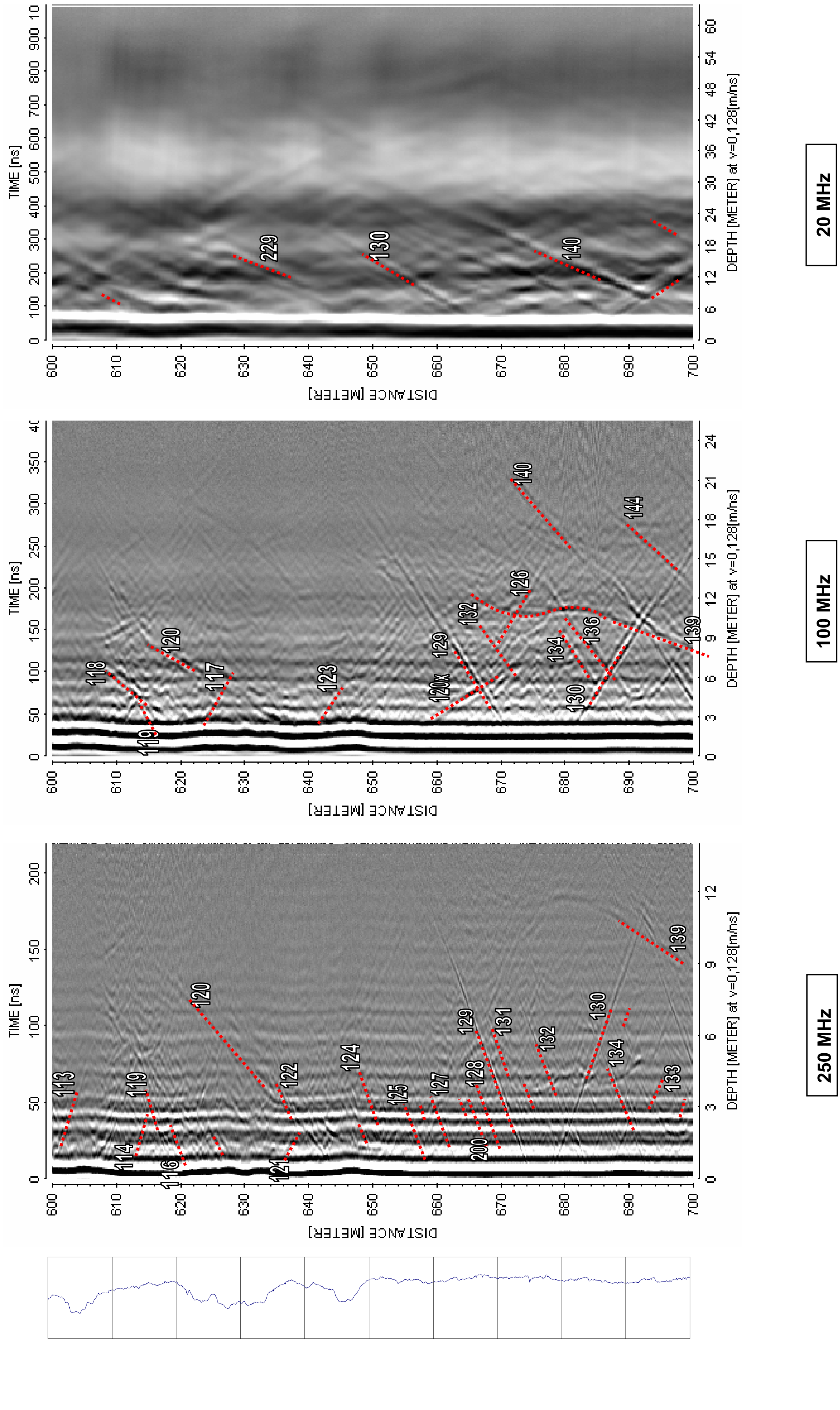
20 MHz


FORSMARK KFM08D
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
78
79
77
80
82
205
84
83
87
88
86
90
89
93
91
94
95
97
71
81
85
92
66
224
225
250 MHz
100 MHz
20 MHz

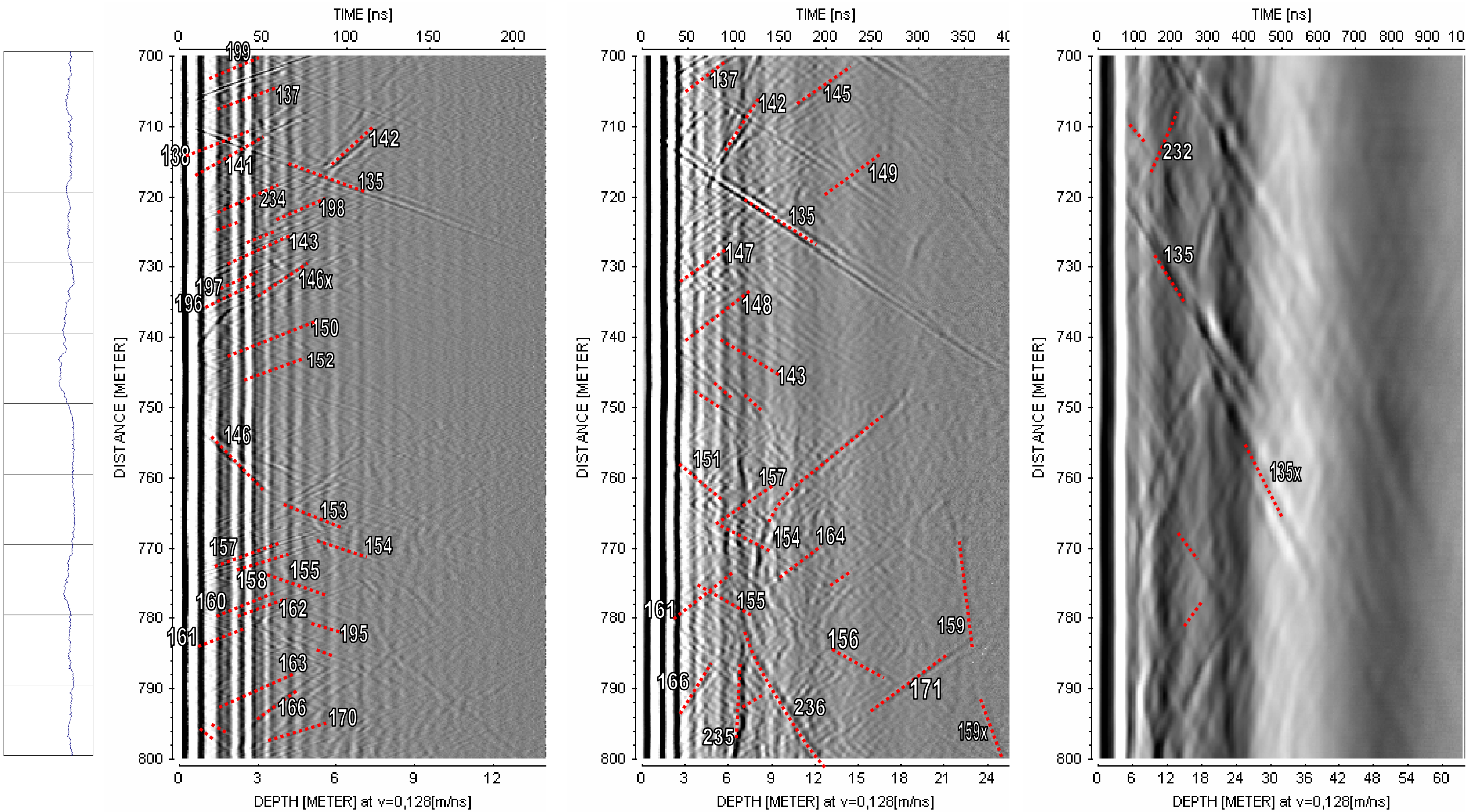
FORSMARK KFM08D



FORSMARK KFM08D



FORSMARK KFM08D

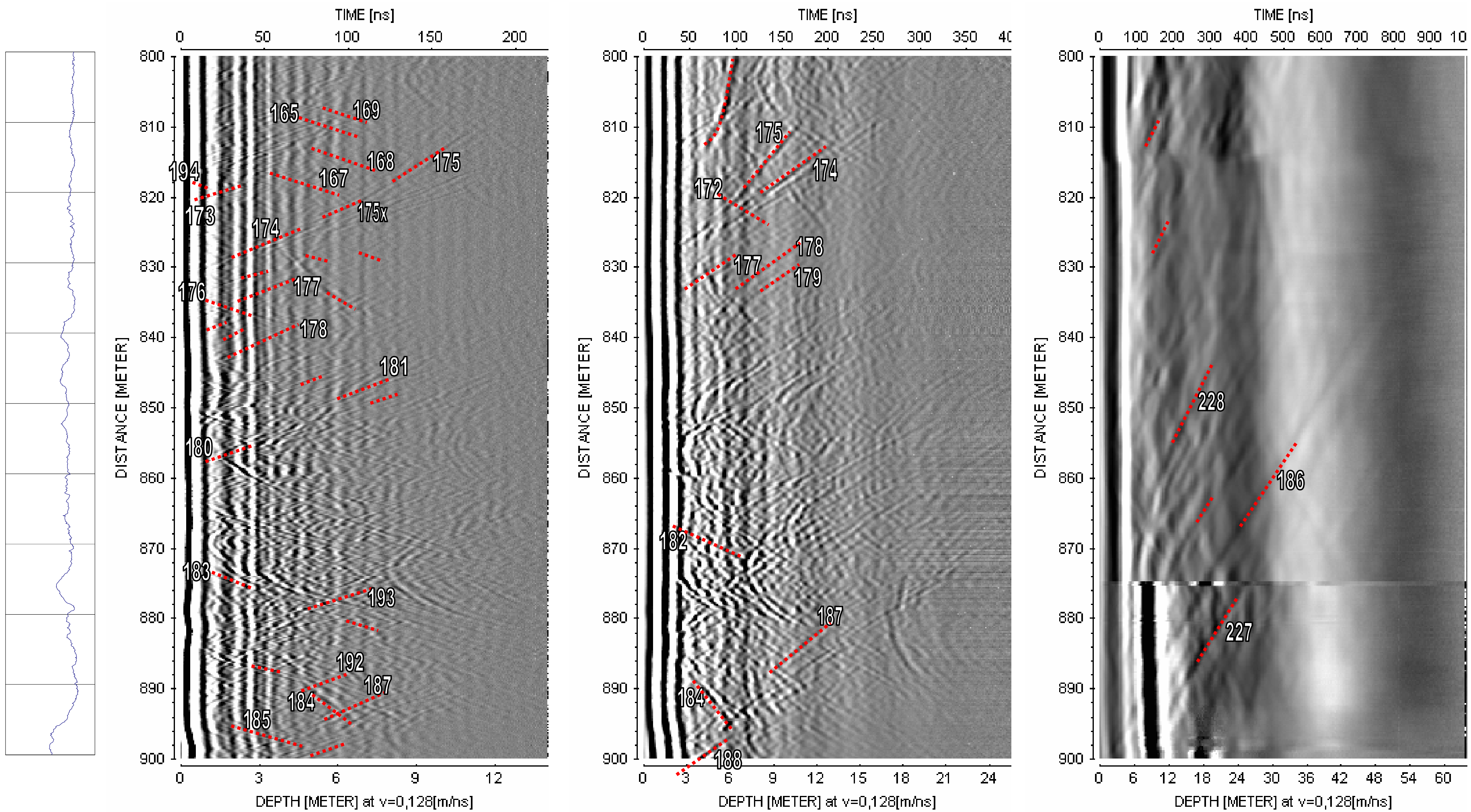


250 MHz

100 MHz

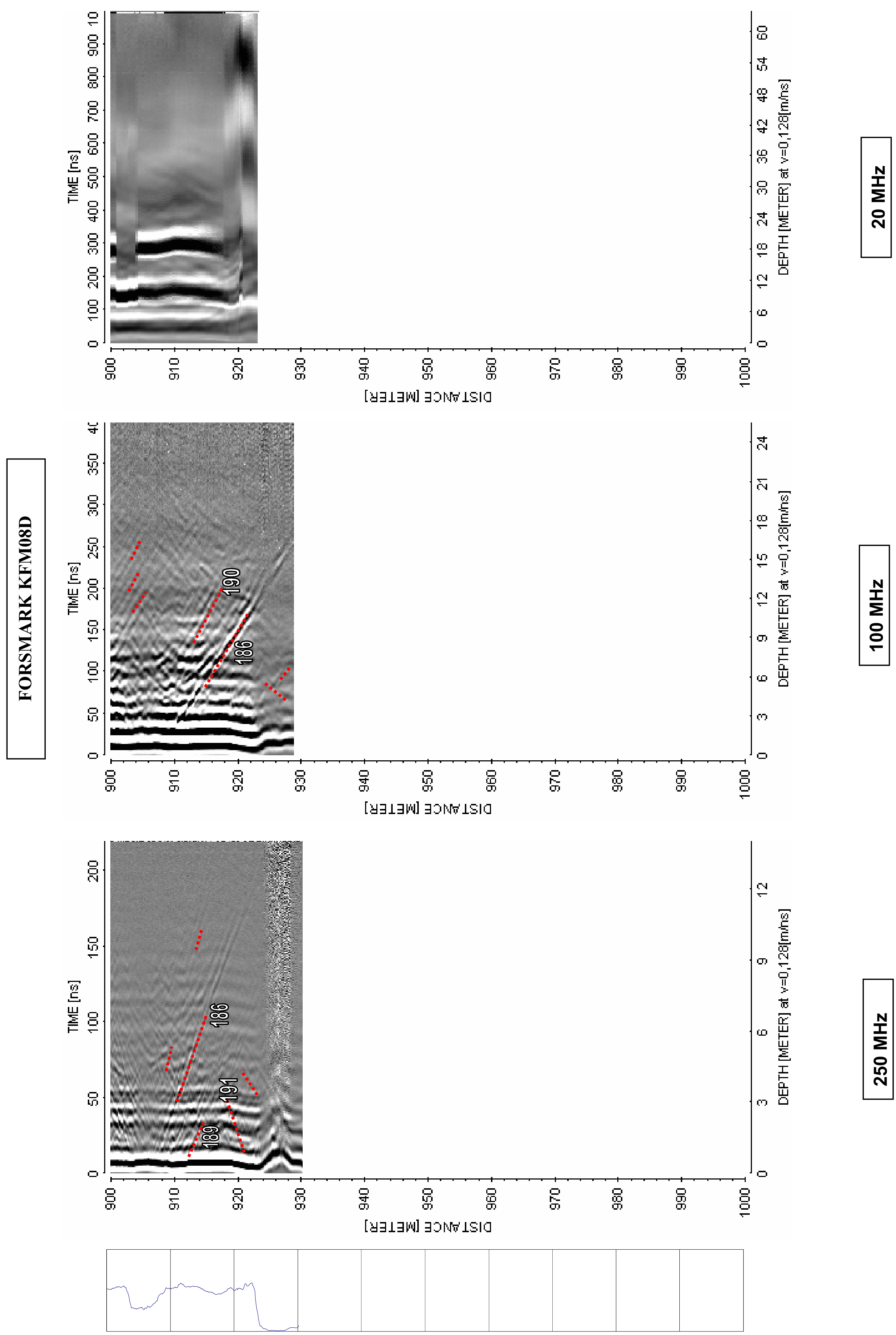
20 MHz

FORSMARK KFM08D



250 MHz

100 MHz



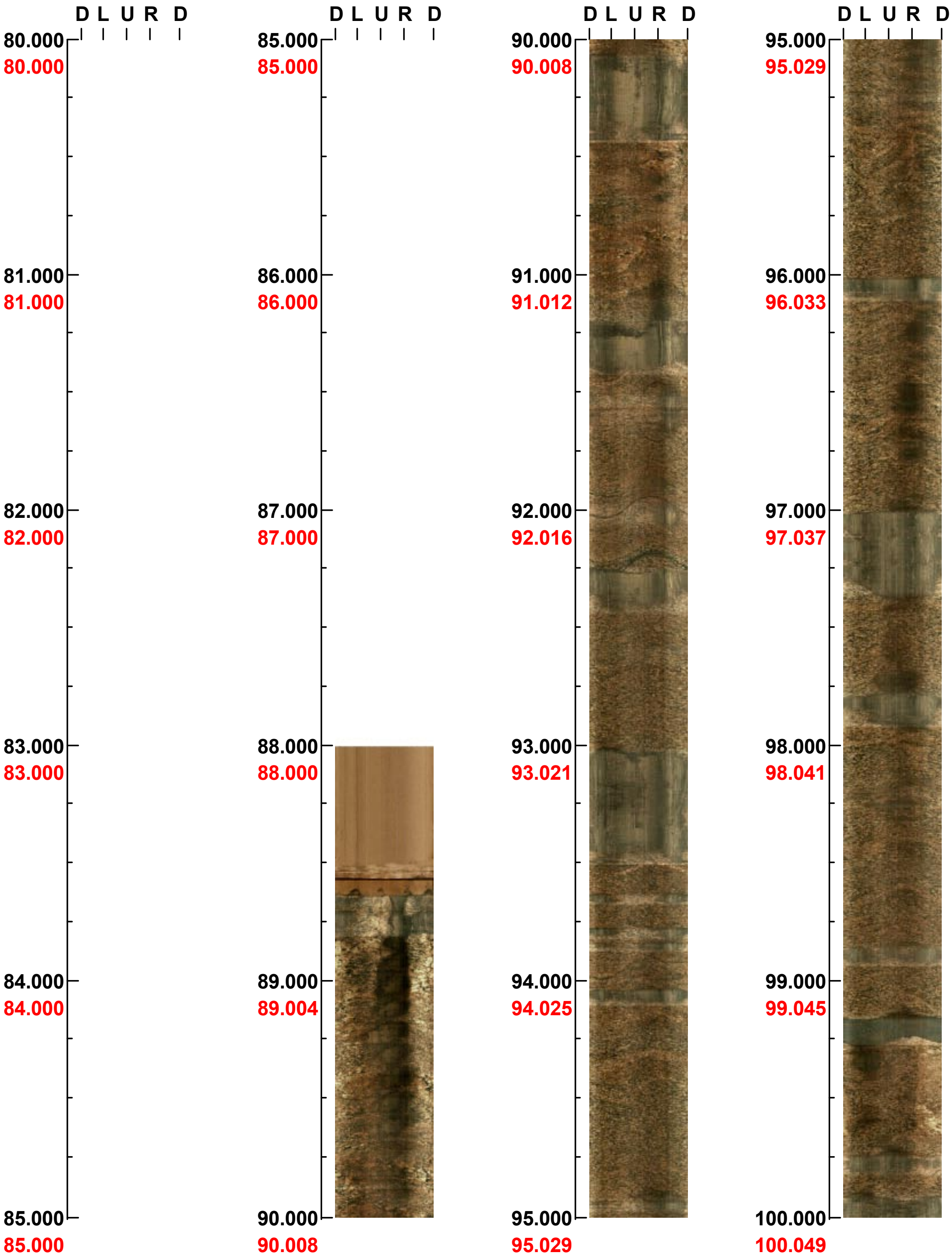
FORSMARK KFM08D
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
186
189
191
190

BIPS logging in KFM02B. 88 to 565 m

Image file	: c:\work\r5599k~1\kfm02b\bips07~1\kfm02b.bip
BDT file	: c:\work\r5599k~1\kfm02b\bips07~1\kfm02b.bdt
Locality	: FORSMARK
Bore hole number	: KFM02B
Date	: 07/02/20
Time	: 16:15:00
Depth range	: 88.000 - 565.765 m
Azimuth	: 313
Inclination	: -80
Diameter	: 76.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 175 %
Pages	: 25
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

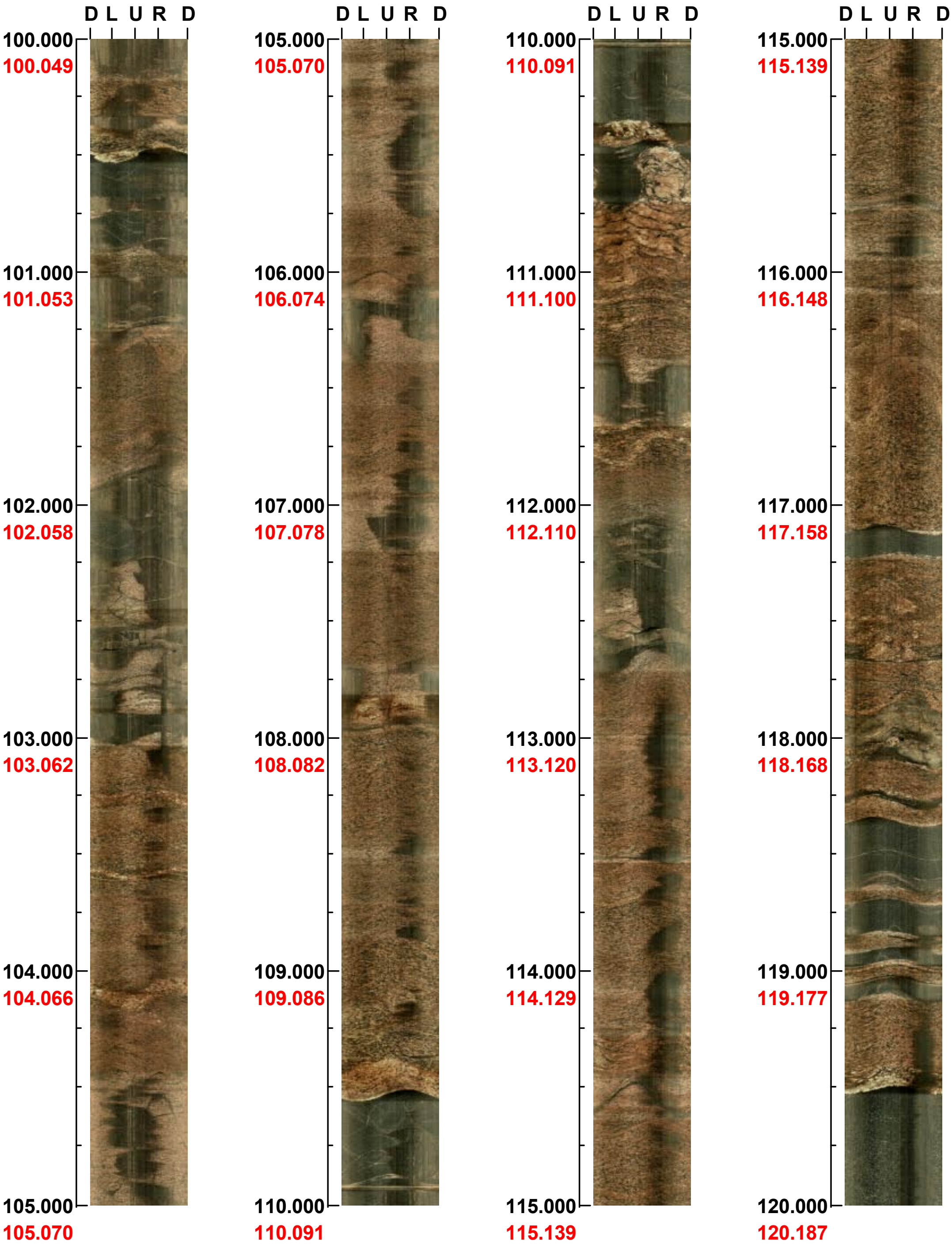
Depth range: 80.000 - 100.000 m



(1 / 25) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

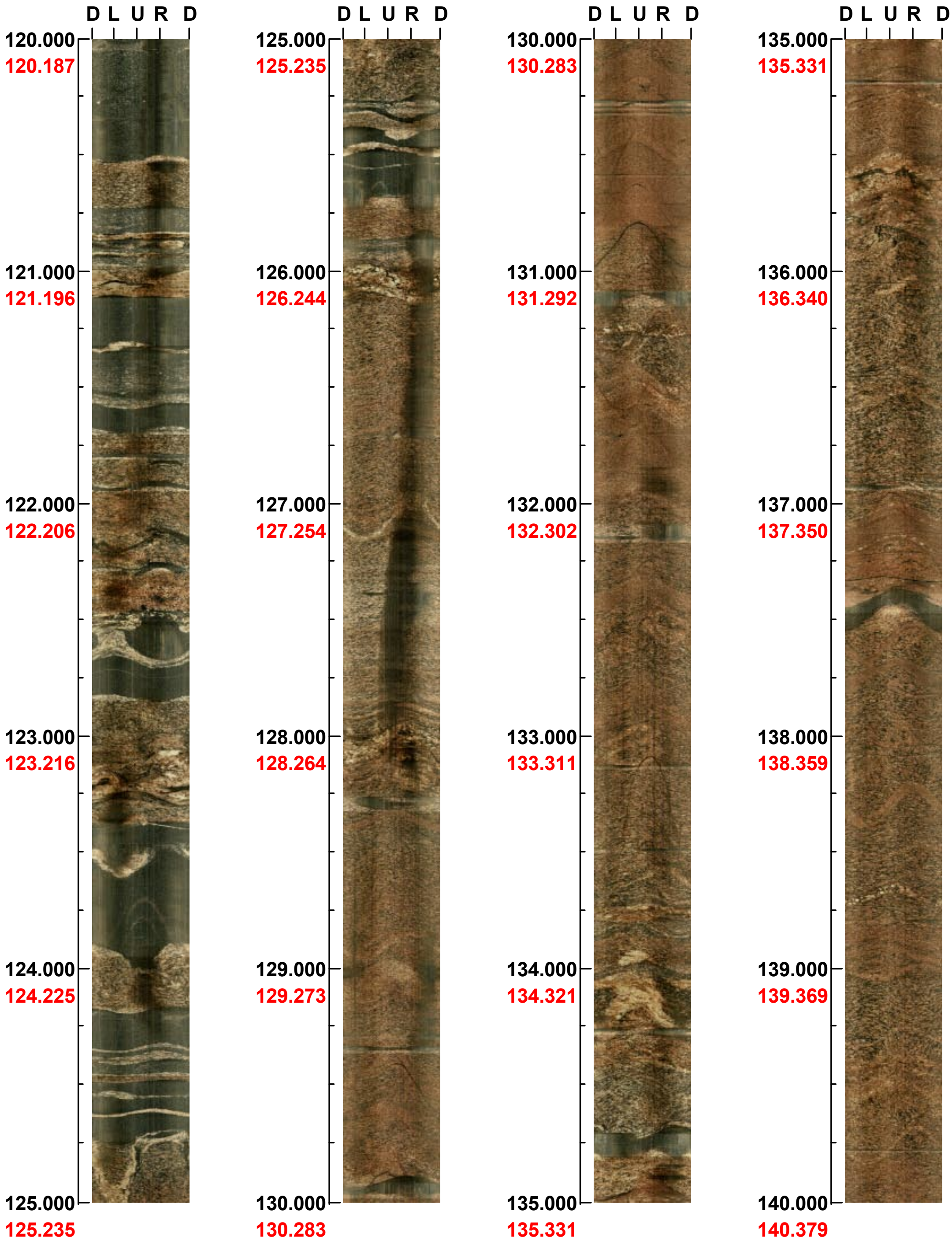
Depth range: 100.000 - 120.000 m



(2 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

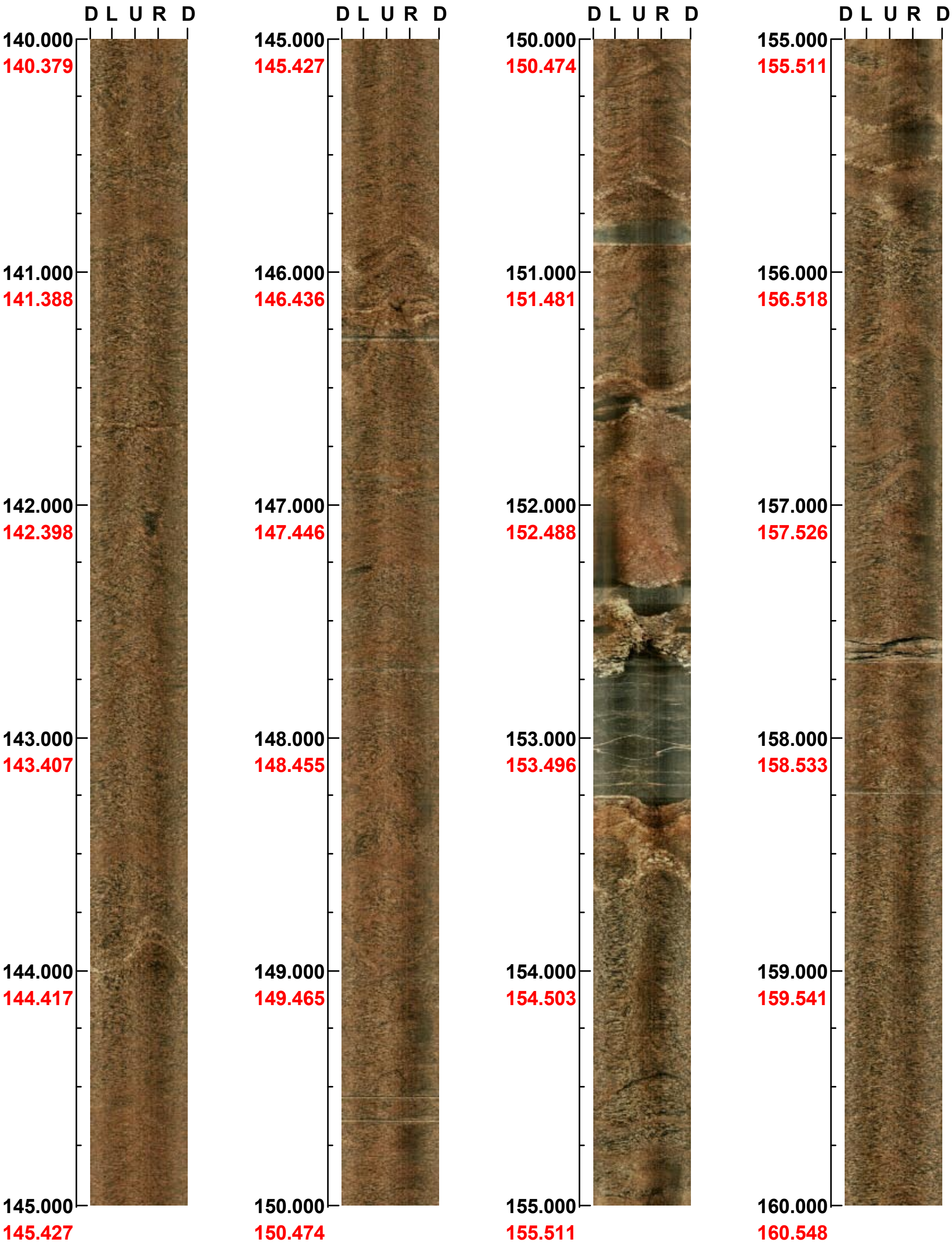
Depth range: 120.000 - 140.000 m



(3 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

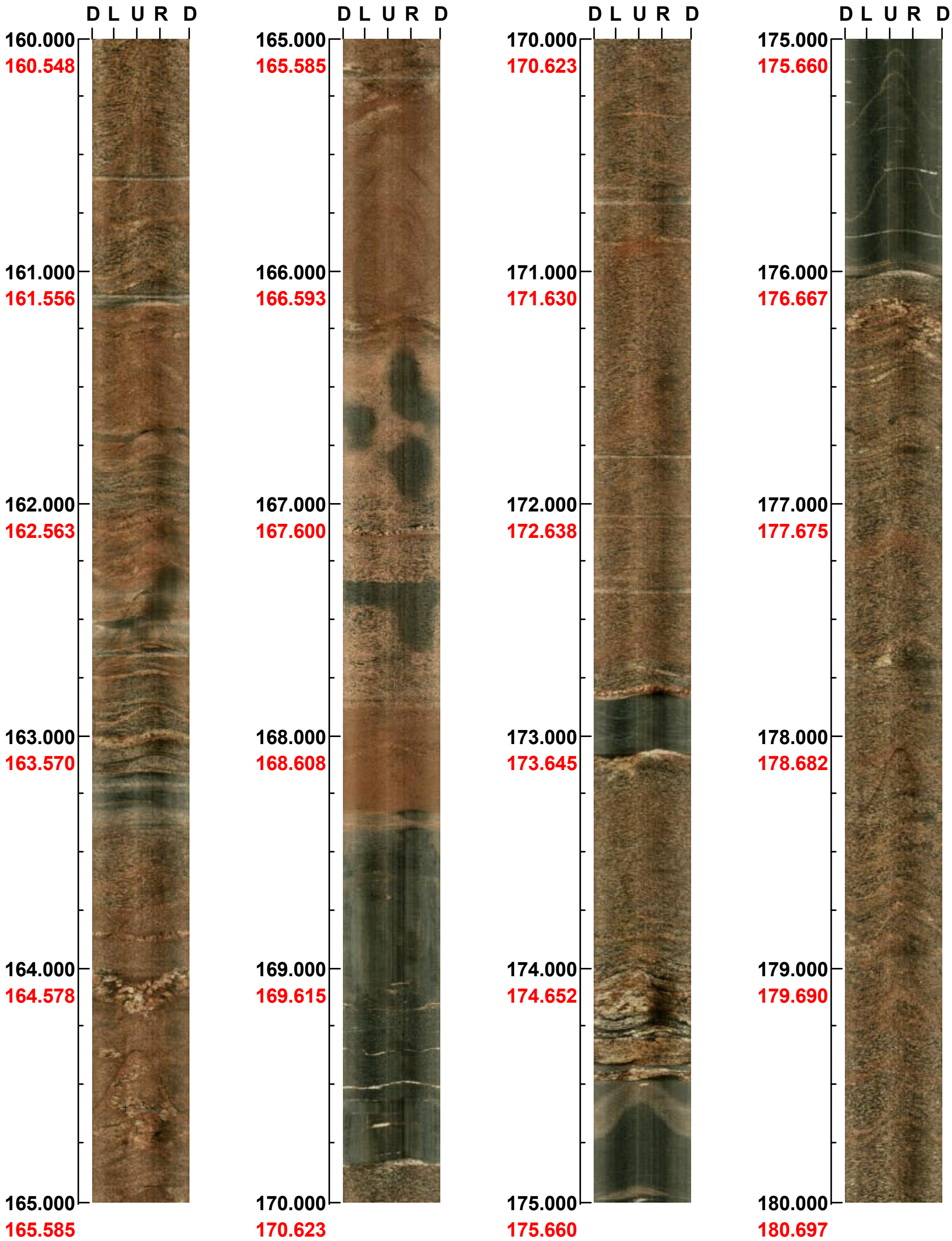
Depth range: 140.000 - 160.000 m



(4 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

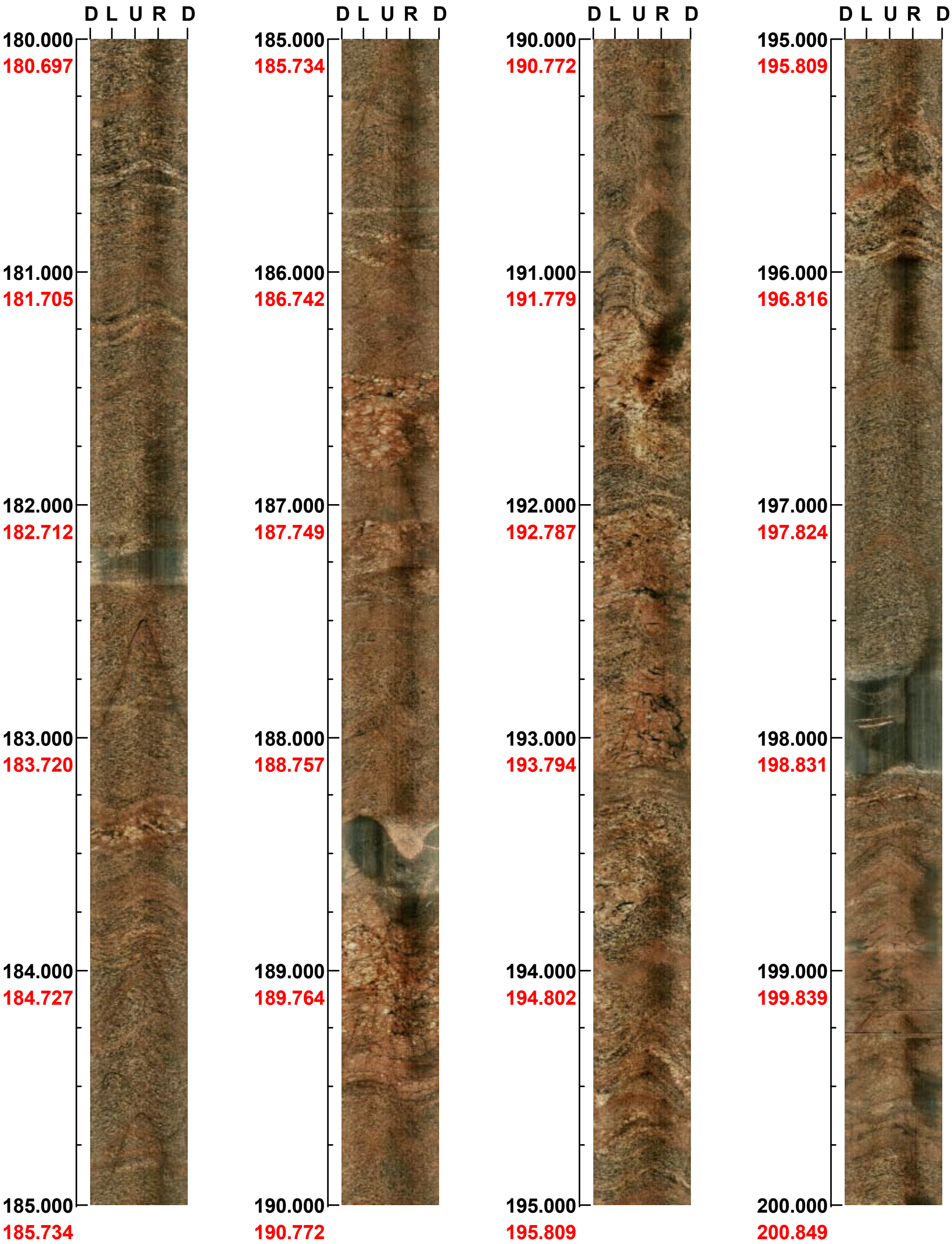
Depth range: 160.000 - 180.000 m



(5 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B Azimuth: 313 Inclination: -80

Depth range: 180.000 - 200.000 m



(6 / 25) Scale: 1/25 Aspect ratio: 175 %

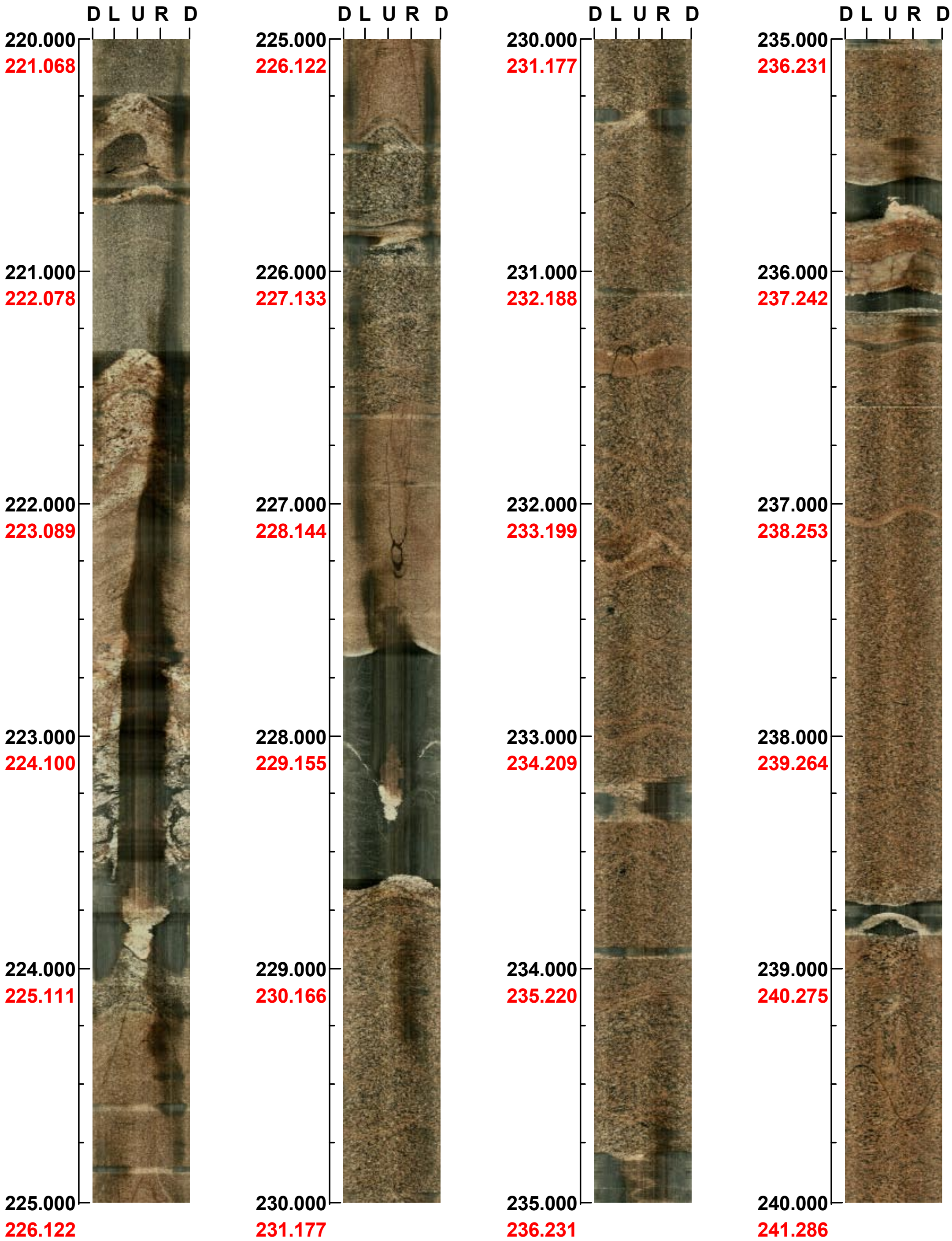
Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 200.000 - 220.000 m

(7 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 220.000 - 240.000 m



(8 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 240.000 - 260.000 m

(9 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 260.000 - 280.000 m

(10 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

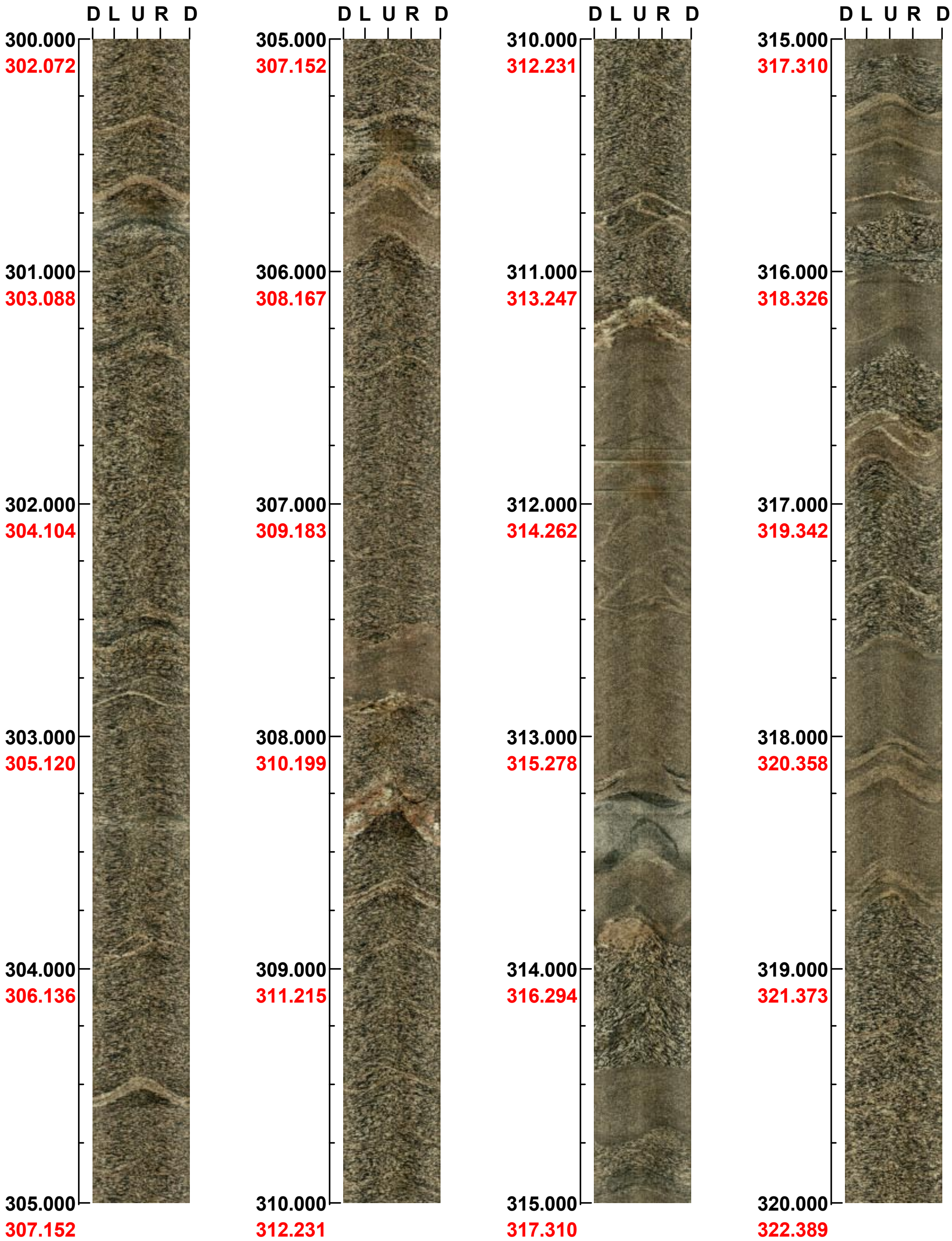
Depth range: 280.000 - 300.000 m

(11 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

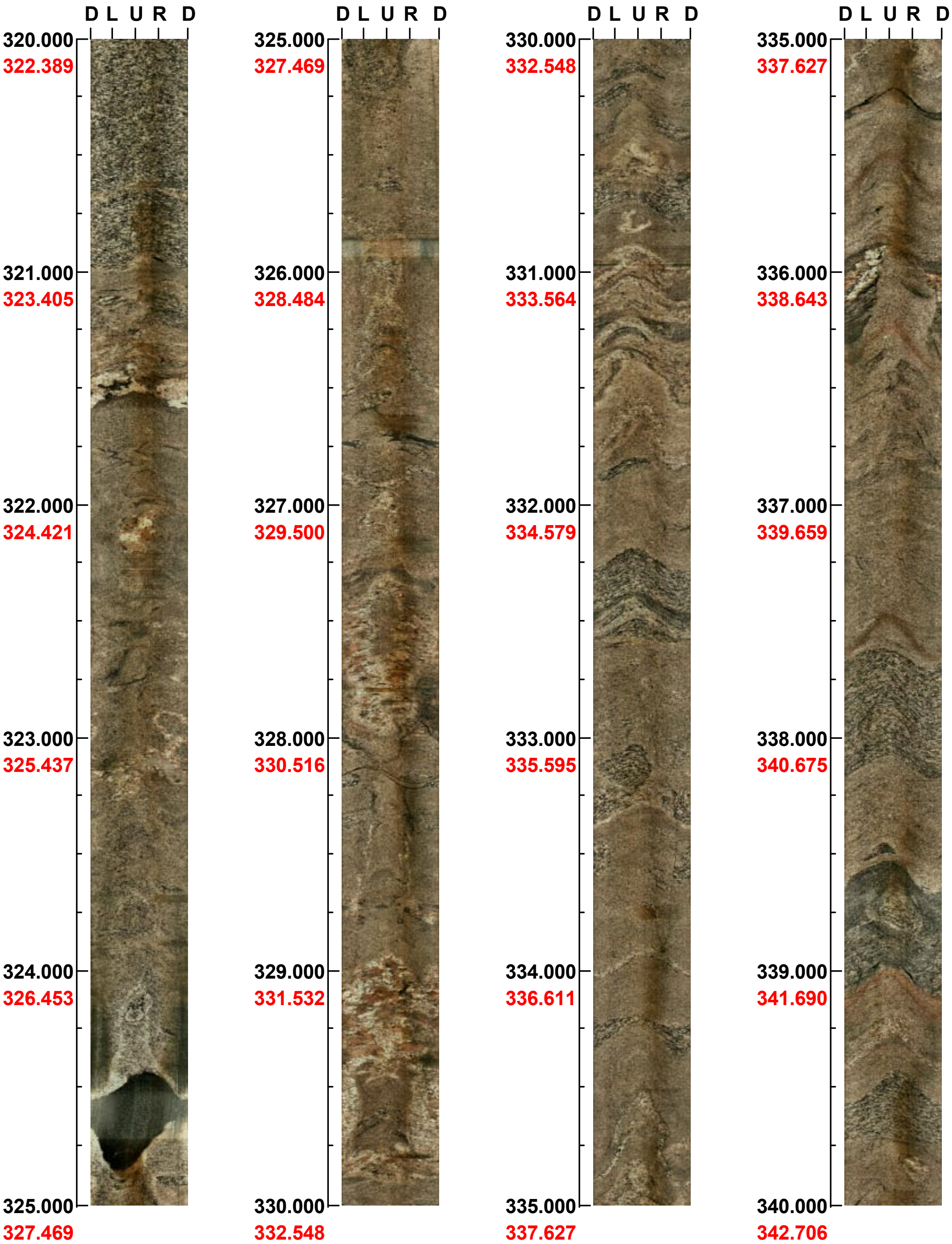
Depth range: 300.000 - 320.000 m



(12 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

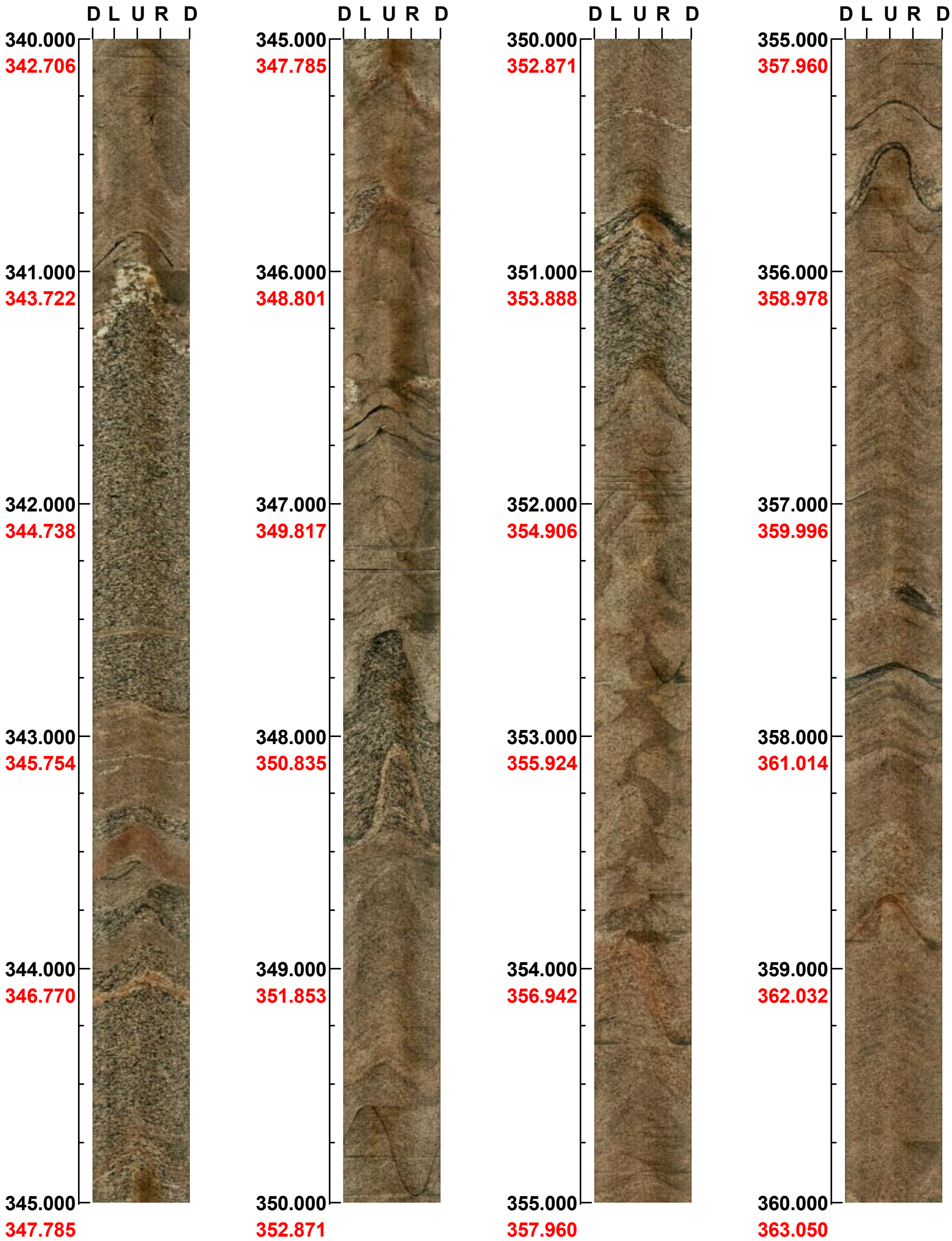
Depth range: 320.000 - 340.000 m



(13 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

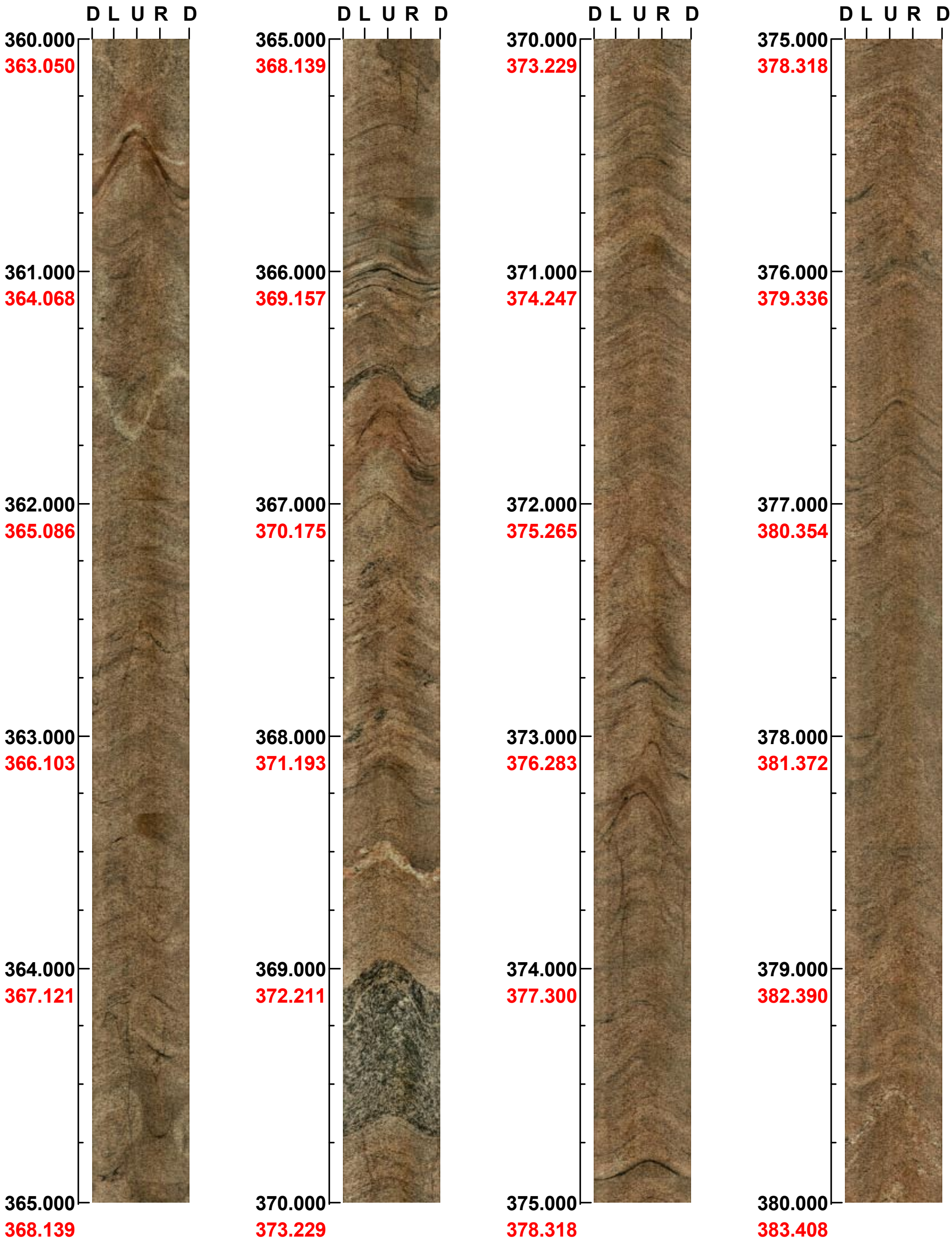
Depth range: 340.000 - 360.000 m



(14 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B Azimuth: 313 Inclination: -80

Depth range: 360.000 - 380.000 m



(15 / 25) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 380.000 - 400.000 m

(16 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 400.000 - 420.000 m

(17 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 420.000 - 440.000 m

(18 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 440.000 - 460.000 m

D L U R D

440.000 / 444.531
441.000 / 445.550
442.000 / 446.569
443.000 / 447.588
444.000 / 448.607
445.000 / 449.626

D L U R D

445.000 / 449.626
446.000 / 450.645
447.000 / 451.664
448.000 / 452.683
449.000 / 453.703
450.000 / 454.722

D L U R D

450.000 / 454.722
451.000 / 455.742
452.000 / 456.761
453.000 / 457.781
454.000 / 458.800
455.000 / 459.820

D L U R D

455.000 / 459.820
456.000 / 460.839
457.000 / 461.859
458.000 / 462.878
459.000 / 463.898
460.000 / 464.917

(19 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 460.000 - 480.000 m

(20 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

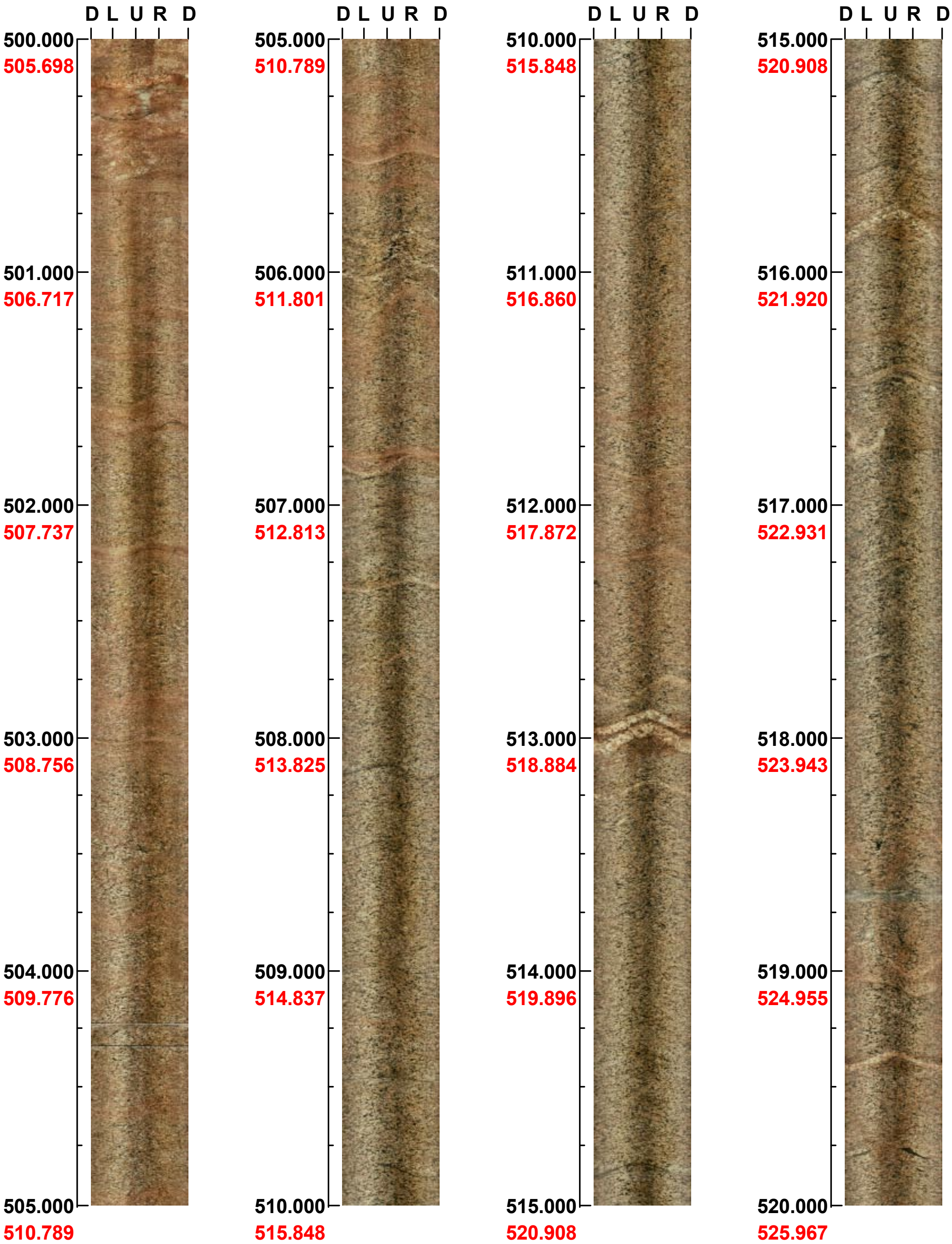
Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 480.000 - 500.000 m

(21 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 500.000 - 520.000 m



(22 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

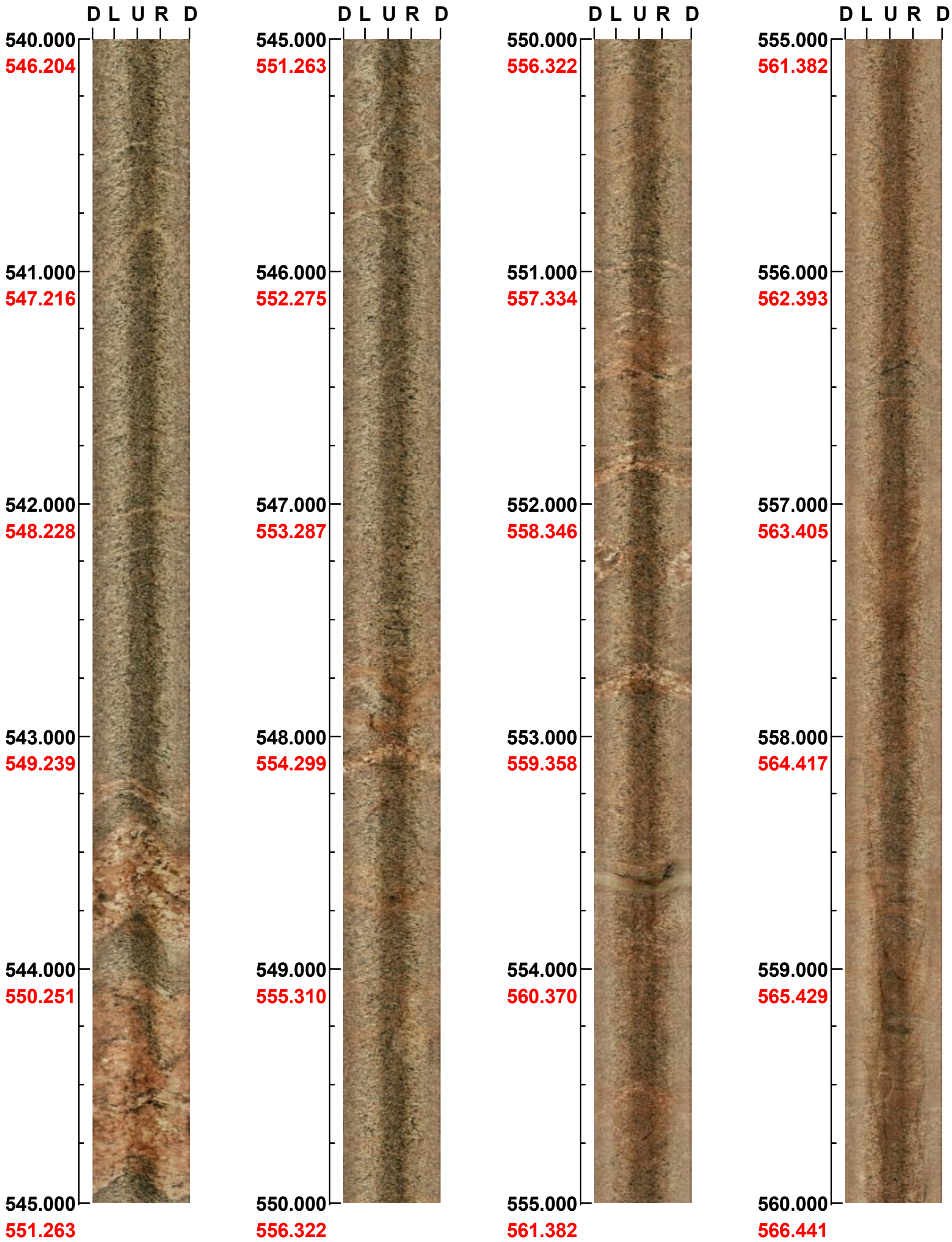
Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

Depth range: 520.000 - 540.000 m

(23 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B **Azimuth: 313** **Inclination: -80**

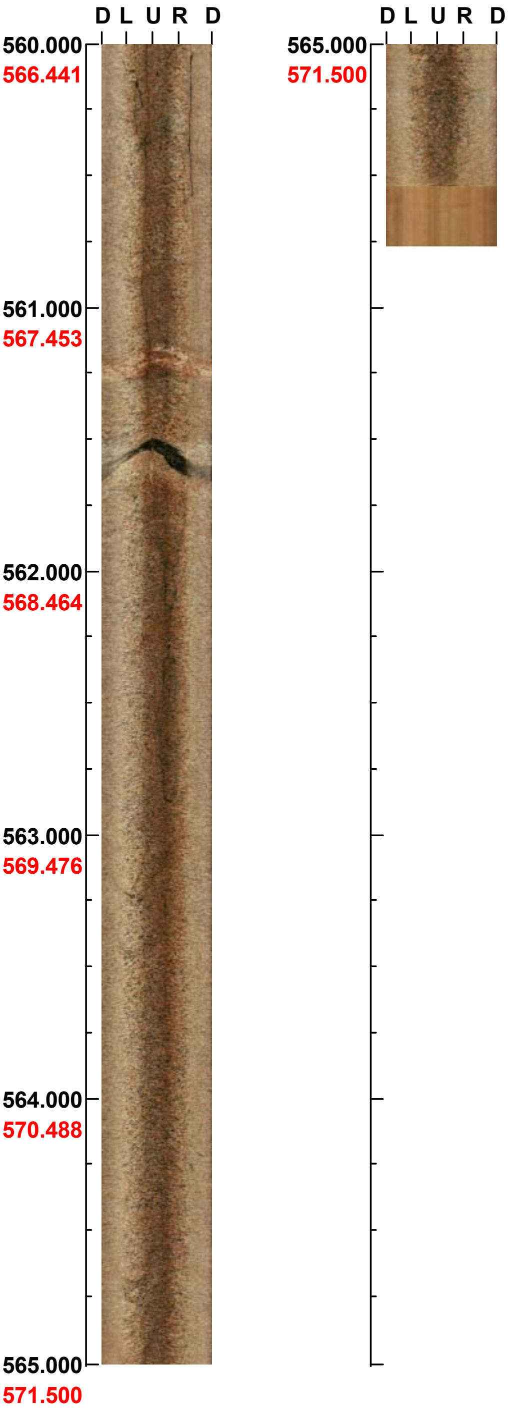
Depth range: 540.000 - 560.000 m



(24 / 25) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM02B Azimuth: 313 Inclination: -80

Depth range: 560.000 - 565.765 m



(25 / 25) Scale: 1/25 Aspect ratio: 175 %

BIPS logging in KFM08D. 60 to 926 m

Project name: Forsmark

Image file	: c:\work\r5599k~1\kfm08d\bips07~2\kfm08d_1.bi
BDT file	: c:\work\r5599k~1\kfm08d\bips07~2\kfm08d_1.b
Locality	: FORSMARK
Bore hole number	: KFM08D
Date	: 07/02/23
Time	: 10:54:00
Depth range	: 60.000 - 926.458 m
Azimuth	: 100
Inclination	: -55
Diameter	: 76.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 175 %
Pages	: 27
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 60.000 - 80.000 m

(1 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

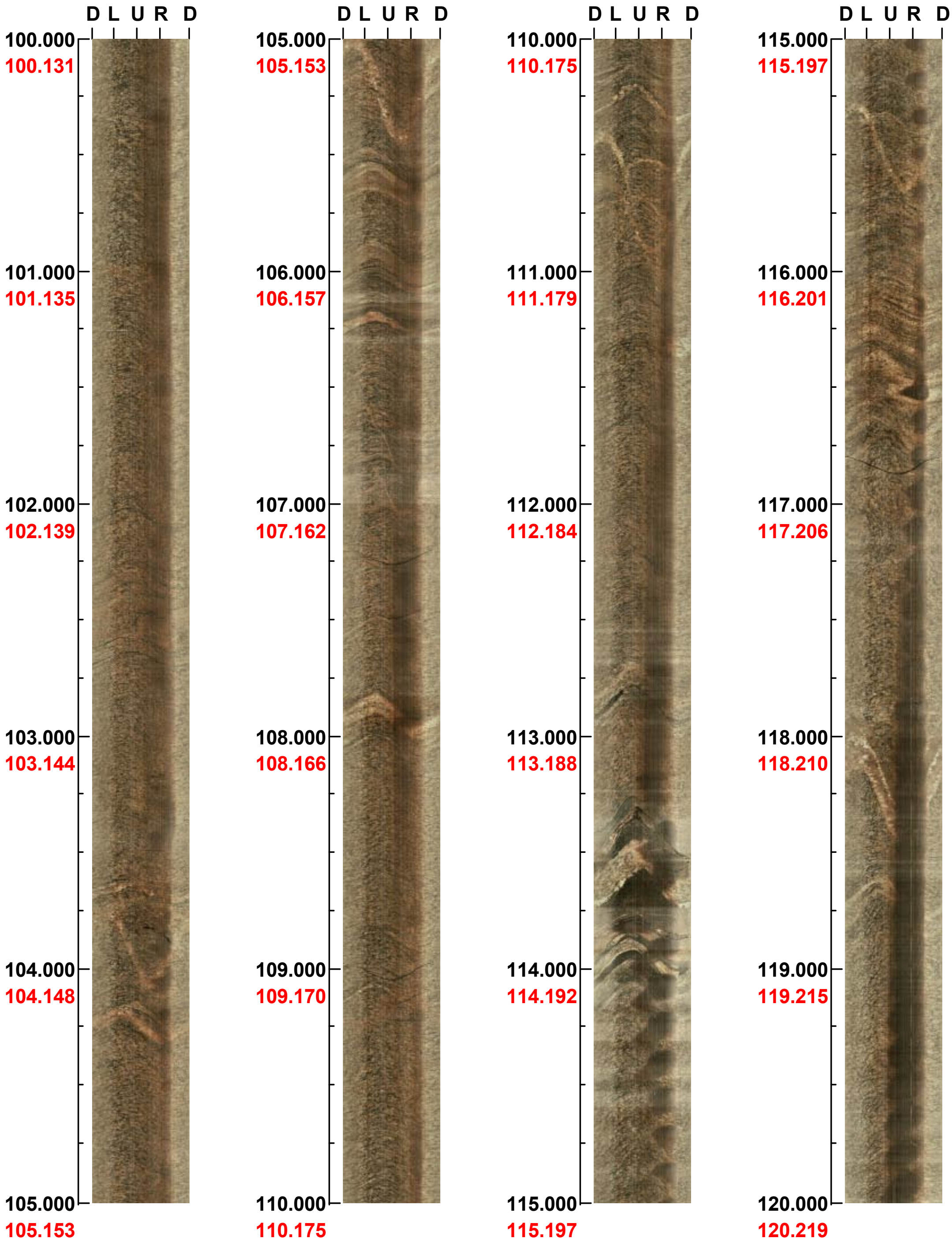
Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 80.000 - 100.000 m

(2 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 100.000 - 120.000 m



(3 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

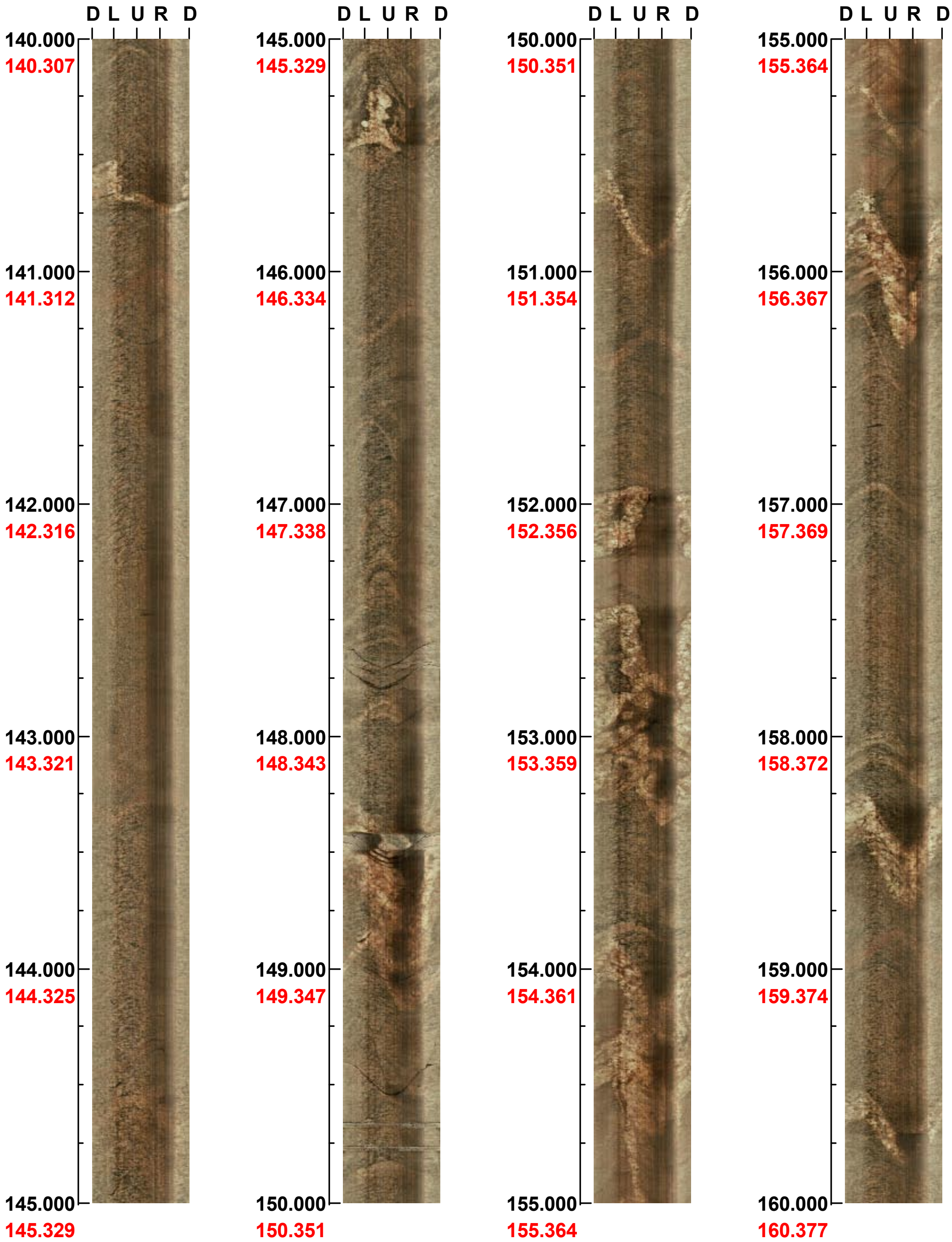
Project name: Forsmark
Bore hole No.: KFM08D Azimuth: 100 Inclination: -55

Depth range: 120.000 - 140.000 m

(4 / 27) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 140.000 - 160.000 m



(5 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

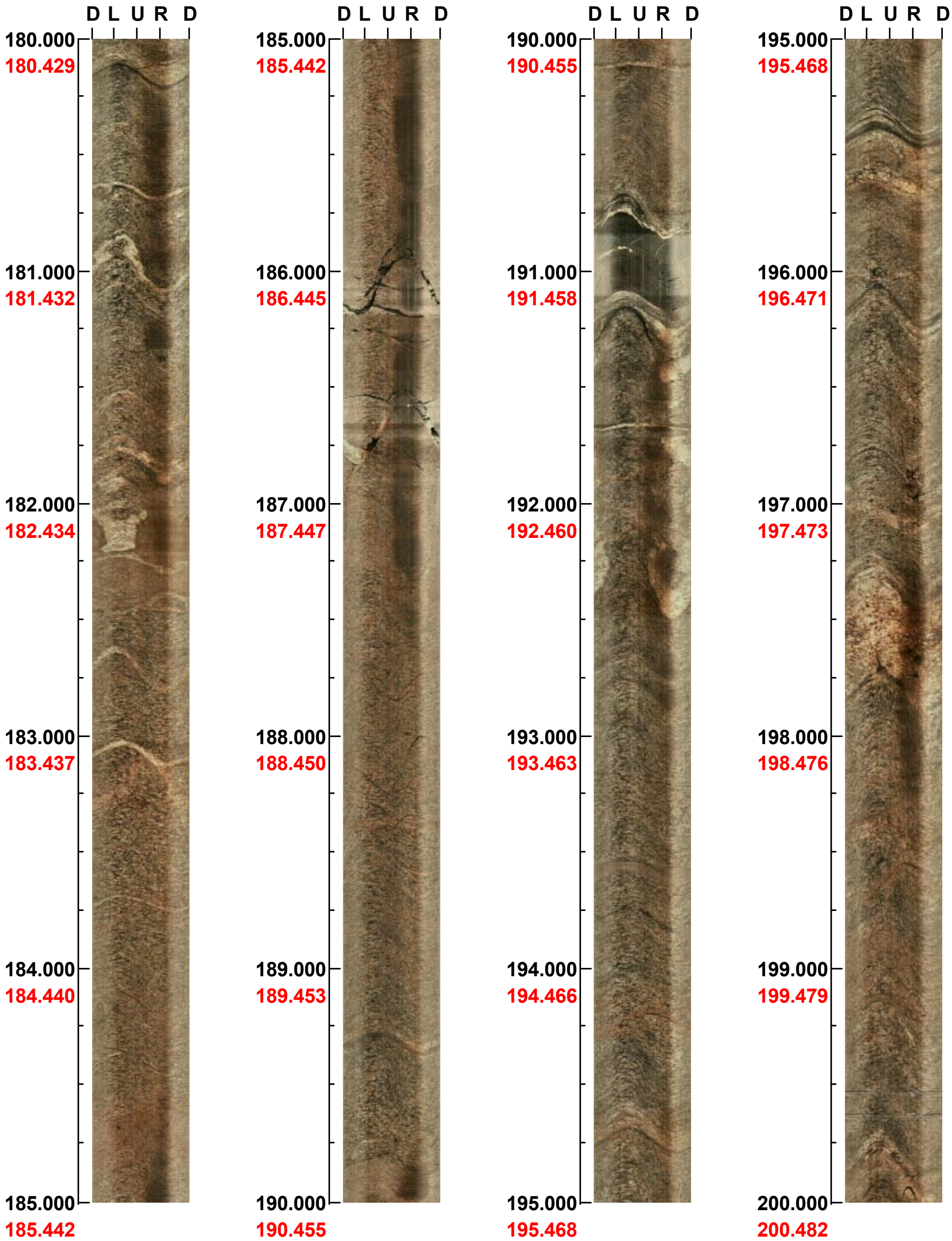
Depth range: 160.000 - 180.000 m

(6 / 27) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 180.000 - 200.000 m



(7 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 200.000 - 220.000 m

(8 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 220.000 - 240.000 m

(9 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D　　Azimuth: 100　　Inclination: -55

Depth range: 240.000 - 260.000 m

(10 / 27)　　Scale: 1/25　　Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08D Azimuth: 100 Inclination: -55

Depth range: 260.000 - 280.000 m

(11 / 27) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 280.000 - 300.000 m

(12 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

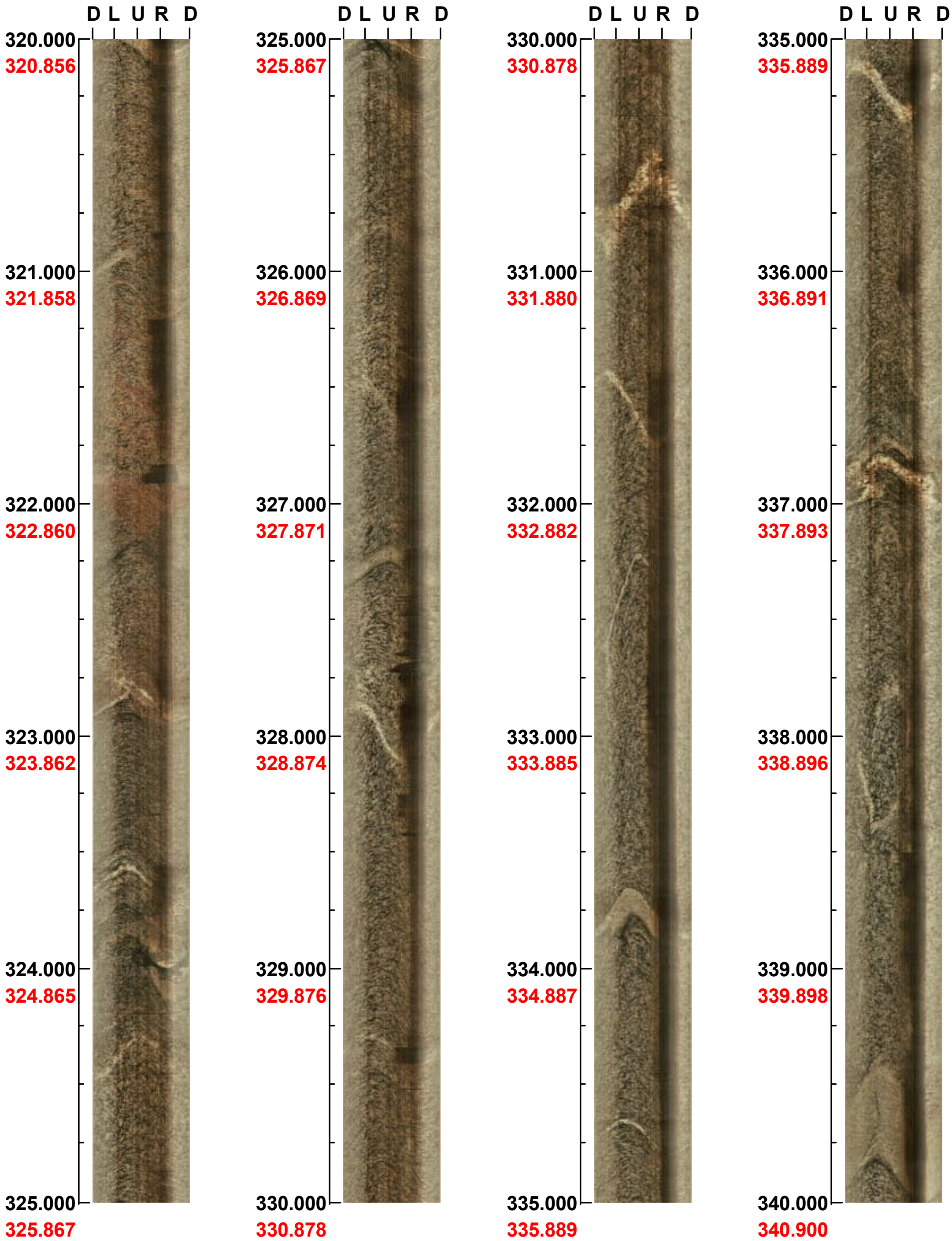
Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 300.000 - 320.000 m

(13 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 320.000 - 340.000 m

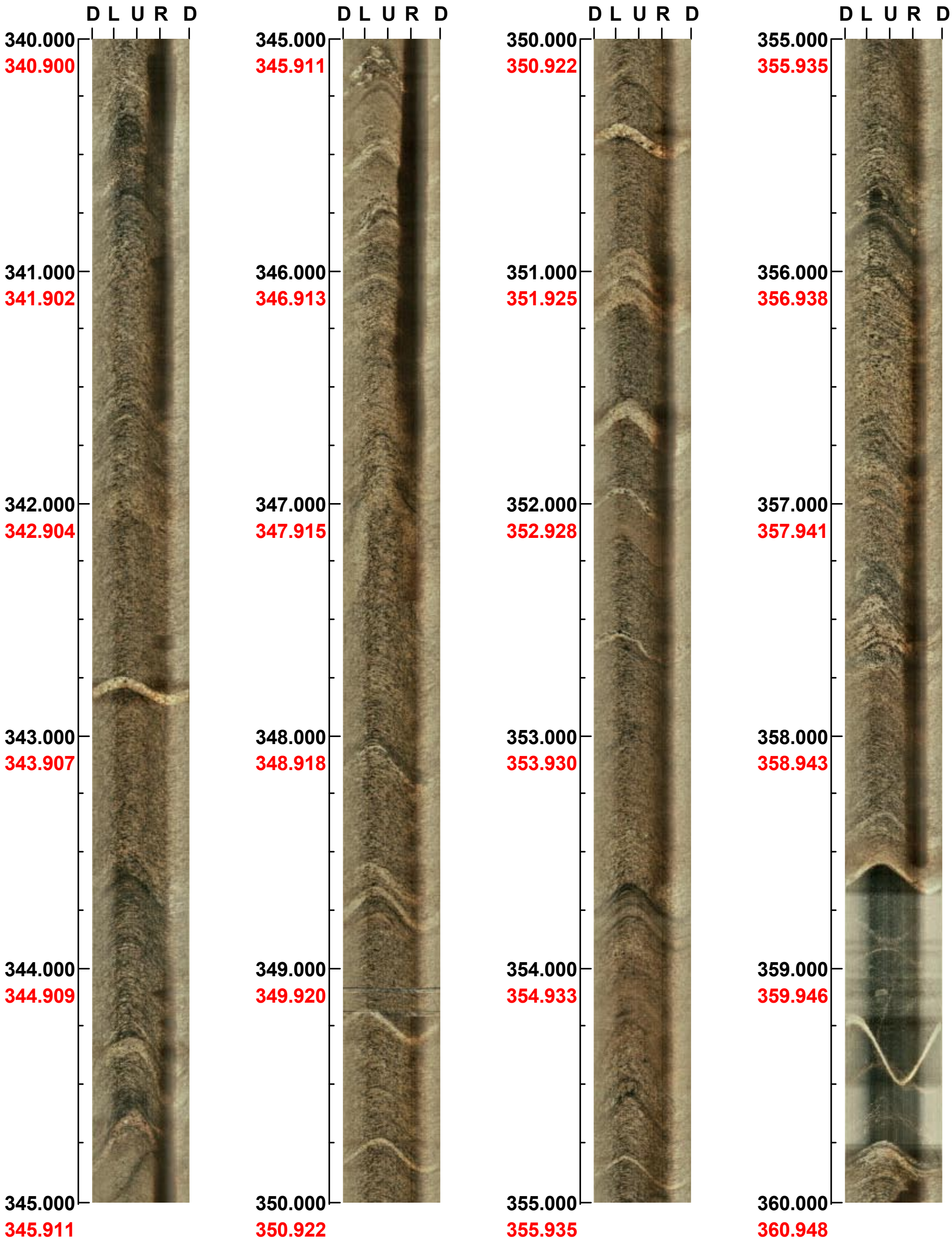


(14 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 340.000 - 360.000 m



(15 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 360.000 - 380.000 m

(16 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 380.000 - 400.000 m

(17 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 400.000 - 420.000 m

(18 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 420.000 - 440.000 m

(19 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D Azimuth: 100 Inclination: -55

Depth range: 440.000 - 460.000 m

(20 / 27) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 460.000 - 480.000 m

(21 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

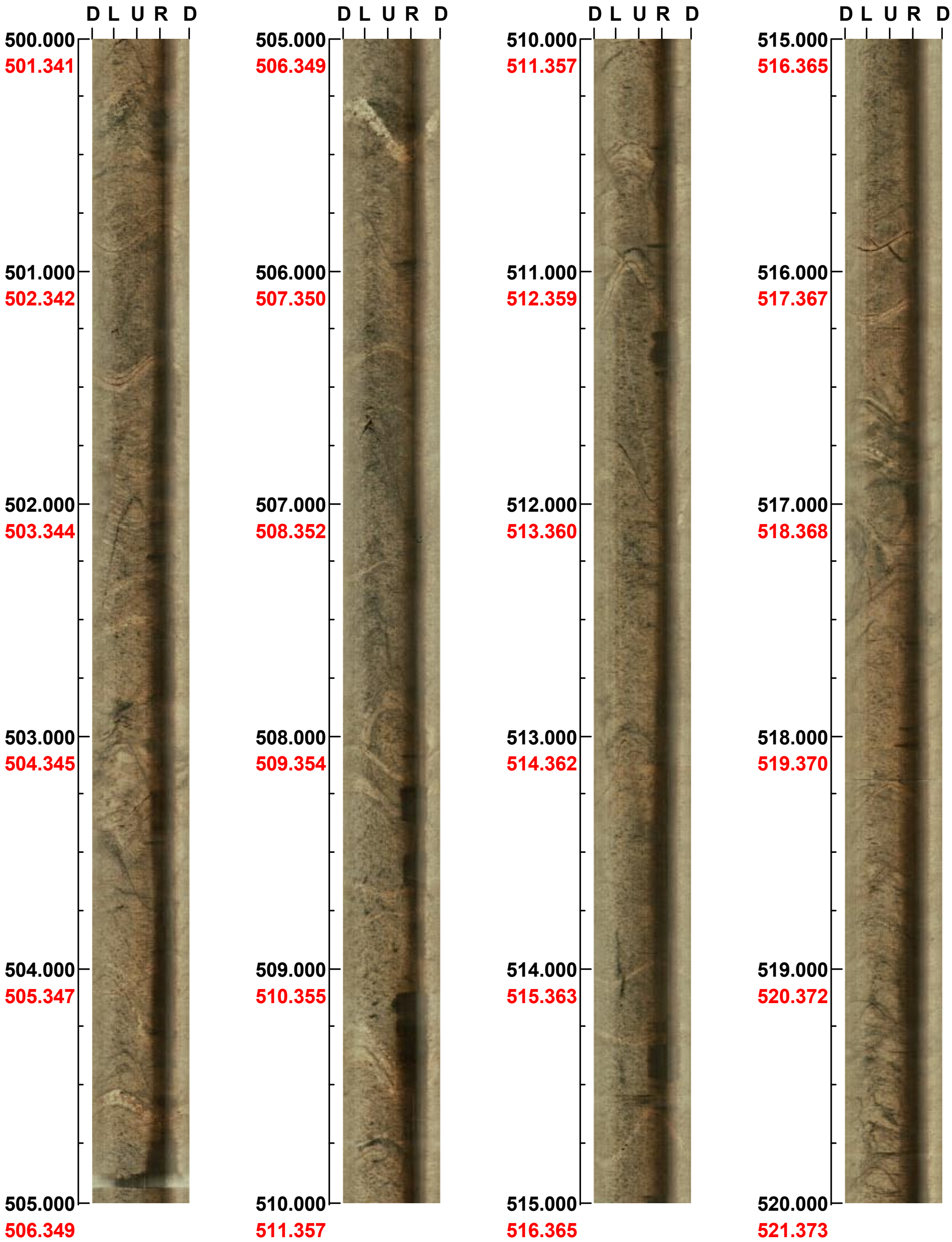
Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 480.000 - 500.000 m

(22 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 500.000 - 520.000 m



(23 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

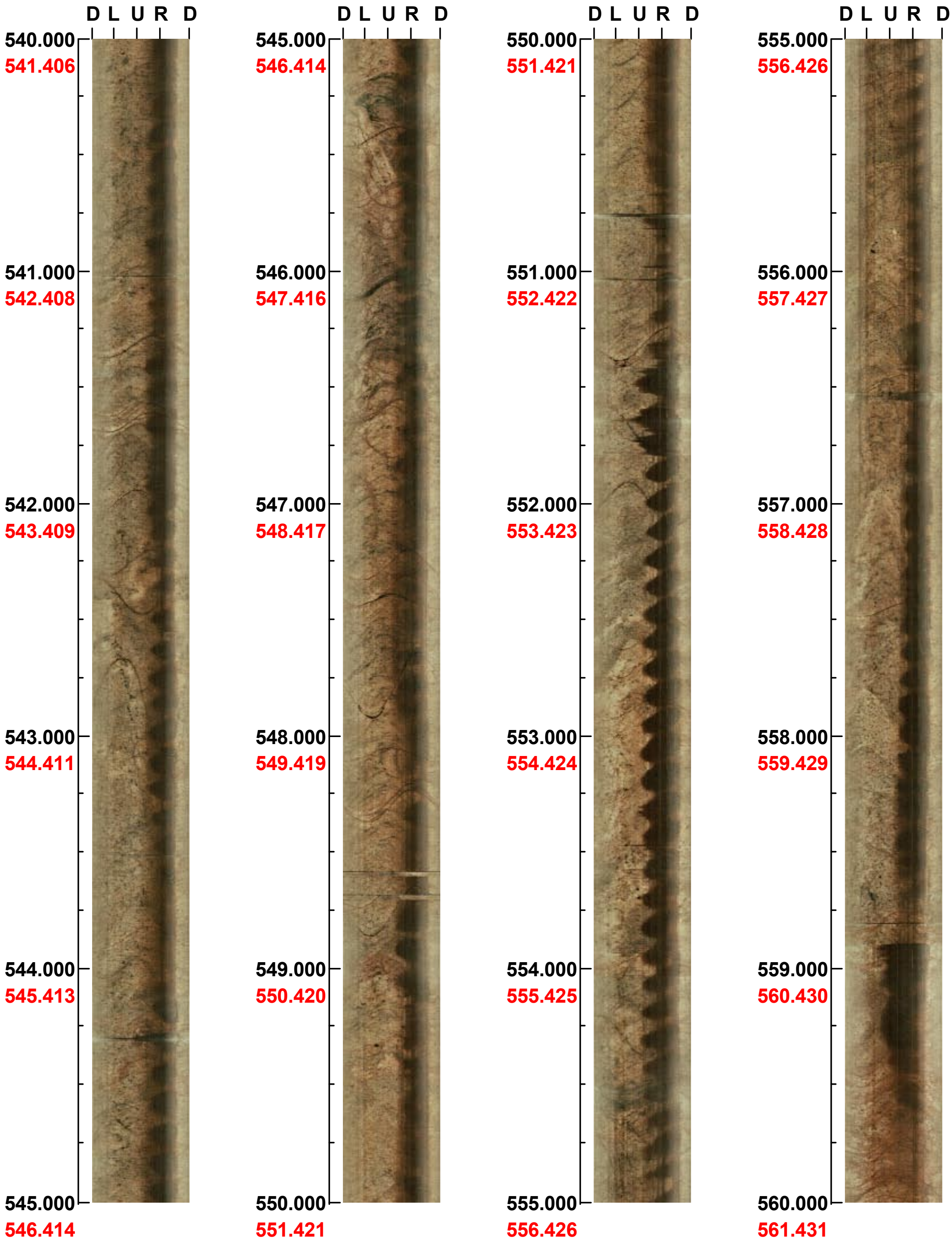
Depth range: 520.000 - 540.000 m

(24 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 540.000 - 560.000 m



(25 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 560.000 - 580.000 m

(26 / 27) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 0** **Inclination: -90**

Depth range: 580.000 - 600.000 m

(1 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 600.000 - 620.000 m

(2 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 620.000 - 640.000 m

(3 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 640.000 - 660.000 m

(4 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 660.000 - 680.000 m

(5 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 680.000 - 700.000 m

(6 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 700.000 - 720.000 m

(7 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D Azimuth: 100 Inclination: -55

Depth range: 720.000 - 740.000 m

(8 / 18) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 740.000 - 760.000 m

(9 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 760.000 - 780.000 m

(10 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 780.000 - 800.000 m

(11 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 800.000 - 820.000 m

(12 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

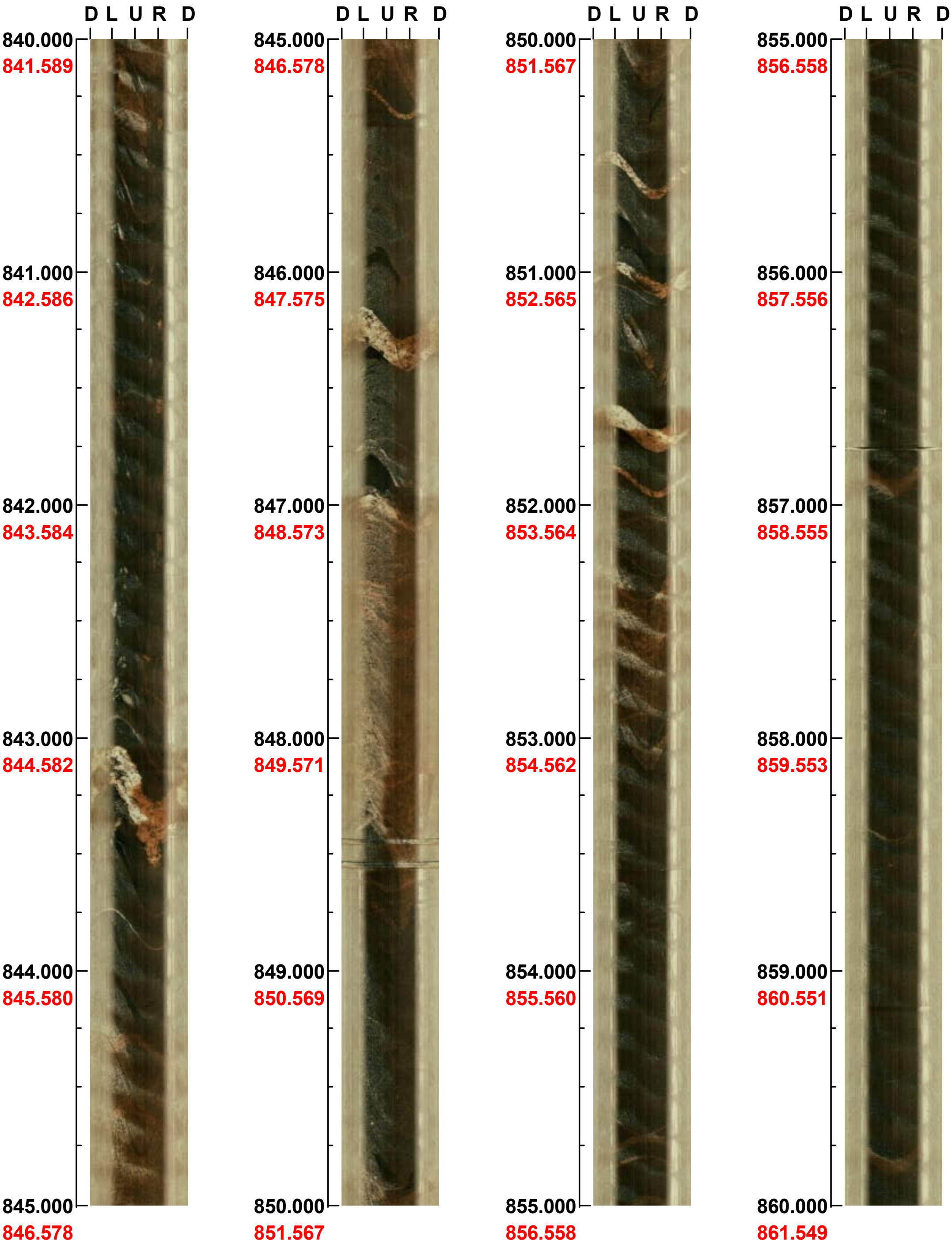
Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 820.000 - 840.000 m

(13 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 840.000 - 860.000 m



(14 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 860.000 - 880.000 m

(15 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 880.000 - 900.000 m

(16 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

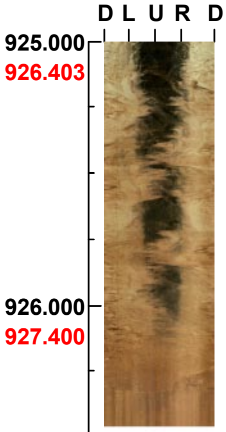
Depth range: 900.000 - 920.000 m

(17 / 18) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08D **Azimuth: 100** **Inclination: -55**

Depth range: 920.000 - 926.453 m



(18 / 18) **Scale: 1/25** **Aspect ratio: 175 %**